Proposed Leasing within the COSO Known Geothermal Resource Area

Draft Environmental Impact Statement

Prepared by

Bakersfield District
Department of the Interior
Bureau of Land Management

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

IN REPLY REFER TO

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
STATE OFFICE
Federal Office Building
2800 Cottage Way
Sacramento, California 95825

Dear Reader:

Enclosed for your review and comment is the draft environmental impact statement on the proposed geothermal leasing program within the Coso Known Geothermal Resource Area in Inyo County, California.

Alternatives considered are: (1) no leasing; (2) lease all lands except those of significant surface conflict; (3) partial deferred leasing to protect cultural resources; (4) lease with no surface disturbance on lands with significant surface conflict; (5) defer leasing until completion of Federal testing of the geothermal resource; (6) staged leasing by zones of geothermal potential; and (7) unitization at time of leasing.

Written comments concerning the draft EIS will be accepted until May 12, 1980. Comments should be sent to District Manager, Bakersfield, California, 93301; telephone- (805) 861-4191.

There will be one public meeting on May 1, 1980 in Lone Pine, California at the Lone Pine Townhall at 7:00 PM. Comments on the draft EIS received in the mail and at the public meeting will be considered in preparing the final EIS. Comments received verbally at the public meeting should be accompanied by written comments to insure that they are accurately interpreted. A decision on geothermal leasing within the Coso KGRA will be made after the final EIS is completed.

Sincerely,

John E. Bail

State Director

Enclosure:
Draft EIS

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

PROPOSED LEASING WITHIN THE COSO KNOWN GEOTHERMAL RESOURCE AREA INYO COUNTY, CALIFORNIA

PREPARED BY

DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
BAKERSFIELD DISTRICT

Ed Hastey

ACTING DIRECTOR, BUREAU OF LAND MANAGEMENT

SUMMARY

(X) Draft ( ) Final Environmental Impact Statement

1. Type of Action: (X) Administrative ( ) Legislative

2. Brief Description of Action:

The BLM proposes to offer competitive and non-competitive geothermal leases on a major portion of the Coso KGRA, Inyo County, California. The Coso Geothermal Study Area (CGSA) covers 72,640 acres centered on public land and lands within the western side of the China Lake Naval Weapons Center. It includes some private and NWC acquired lands which would be unavailable for leasing. The EIS assumes a geothermal potential within the CGSA of 600 MW, and a development model of eleven 50 MW generating stations, plus a probable 50 MW plant to be installed under the Navy's geothermal development program.

3. Summary of Environmental Impacts:

Approximately 2150 acres would be disturbed over time by the proposed action of leasing. An additional estimated disturbance of 110 acres from the Navy's geothermal development program is addressed as an accumulation of impacts which would occur concurrently. Fugitive dust emissions should not normally exceed 100 ug/m^3 which is within all government TSP standards. Local H_2S levels may increase up to the State's one-hour average standard of 30 ppb. Visibility may decrease under worst case conditions from 61 miles to 51 miles. Localized noise level increases would occur and would disturb sensitive receptors. If ground water is used from Rose Valley, the water table would be lowered, with a potential for drying Little Lake. Flow to Coso Hot Springs could be altered. Wind and water erosion would occur on disturbed soils. The wildlife community structure would be adversely affected. If Little Lake were lowered, waterfowl dependent upon it would be adversely affected and the local population of Spartina gracilis would be adversely affected. Some visual degradation would occur. Some loss of cultural resources would have to occur unless geothermal development activities were greatly restricted to cleared areas. A new land use, geothermal development, would be imposed upon an area of open space and NWC research and testing activities. The NWC mission should not be substantially hindered. Public fiscal burdens imposed by the need for additional infrastructure may occur before geothermal revenues accrue and are shared with the State.

Native American use of the Coso Hot Springs and the Prayer Site should not be interfered with if proposed mitigation is implemented. The integrity of Coso Hot Springs, highly valued by the Native Americans, may be lessened.

4. Alternatives Considered:
   a. No Action-Offer No Leases.
   b. Lease all lands except those with significant surface conflicts.
   c. Partial deferred leasing to protect cultural resources.
   d. Lease with no surface disturbance on lands with significant conflicts.
   e. Defer leasing until a Federal geothermal testing program can be implemented.
   f. Unitization at leasing stage.

5. Comments have been requested from the following: See Attached

6. Date Draft Statement Made Available to the Environmental Protection Agency and the public: April 1980

ATTACHMENT

Comments on the Draft EIS will be requested from the following agencies.

<u>Federal Agencies</u>

Department of Agriculture
- Forest Service
- Soil Conservation Service
- Rural Electrification Administration

Department of Commerce
Department of Defense
Department of Energy
Department of Health, Education and Welfare
Department of Housing and Urban Development
Department of the Interior
- U.S. Fish and Wildlife Service
- Geological Survey
- Heritage Recreation and Conservation Service
- Bureau of Indian Affairs
- Bureau of Mines
- National Park Service
- Water and Power Resources Service

Department of Labor
Department of Transportation
Environmental Protection Agency
Federal Aviation Administration
National Advisory Council on Historic Preservation

California State Clearinghouse

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FOREWORD

This Environmental Statement (ES) has been prepared by Rockwell International for the Bureau of Land Management under contract YA-512-CT8-216. The ES team consisted of the Environmental Monitoring & Services Center (EMSC) of Rockwell International and three firms under subcontract to Rockwell. These firms are:

Environmental Resources Group (ERG) - Los Angeles, California. Resource areas of responsibility include Wildlife, Flora, Cultural Resources, Land Use, and Socioeconomics.

Harding-Lawson Associates (HLA) - Novato, California. Resource areas of responsibility are Geology, Hydrology, and Soils.

Bridgers Troller Associates (BTA) - Burbank, California. Responsibility for Visual Resources assessment.

The BLM Contracting Officer's Authorized Representative (COAR) for the project is Ms. Janis Bowles. The BLM technical review team consisted of ten persons of various resource disciplines.

The following individuals contributed to the management of the program:

EMSC Project Director - Dr. George Lauer

EMSC Project Coordinator - Ms. Patricia Casey

ERG Program Manager - Ms. Louise Hall

HLA Program Manager - Mr. Frank Kresse

BTA Program Manager - Mr. Greg Arthur

The following individuals provided significant contributions to the material presented in the ES and the associated Technical Reports (TR):

1. Climatology - Mr. Timothy Waldron and Mr. Bryan Winkler
2. Air Quality - Dr. Charles McDade
3. Noise - Dr. Charles McDade and Mr. Donald Holcomb
4. Geology - Ms. Theodora Coffey and Dr. James Koenig
5. Hydrology - Mr. Richard Weiss, Mr. Michael Bergstrom, and Dr. John Sharp
6. Soils - Dr. Jeffrey Peters, Mr. George Borst, Mr. Rudolf Ulrich,

Ms. Kathy O'Loughlin, Mr. Gary Andrews, Mr. Charles Patterson

7. Wildlife - Dr. C. Robert Feldmeth (Field Ecology and Aquatic Species, Dr. Philip Leitner (Small Mammals and Carnivores), Dr. Daniel A. Guthrie (Avifauna), Dr. Timothy Brown (Herpetofauna), Ms. Susan Woodward (Large Mammals), and Dr. Jerry McDonald (Large Mammals)

8. Vegetation - Dr. James Henrickson and Dr. C.R. Feldmeth

9. Visual Resources - Mr. Samuel W. Bridgers, Mr. Greg Arthur, Mr. Daniel Panetta, Mr. Steven Dee, Mr. Bruce Hostetter, Mrs. Halli Mason, and Mr. James Pickel

10. Cultural Resources - Dr. C. William Clewlow, Mr. David Whitley, and Ms. Helen Wells

11. Land Use - Mr. R. Keith Julian.

12. Socioeconomics - Ms. Louise Hall, Mr. George A. Johnson, Mr. James A. Rabe, and Ms. Gail Jensen

It is the intent of the Bureau of Land Management to present in this Environmental Statement sufficient detail concerning the present environmental setting to permit an individual to assess the degree and importance of the projected impacts should the proposed action be implemented. The ES, as a document is not intended as a technical document for the specialist, however, it has been prepared by selective incorporation of a large body of material which was compiled into a number of Technical Reports. The subjects covered in these TR's are:

1. Air Quality

2. Noise

3. Geology and Hydrology

4. Wildlife and Flora

5. Cultural Resources

The Technical Reports are available to the interested reader by writing to:

Ms. Janis Bowles
Bureau of Land Management
Bakersfield District Office
800 Truxtun Ave.
Bakersfield, California 93301

1.0 PROPOSED ACTION

1.1 SCOPE

The purpose of the Coso Geothermal Leasing Environmental Statement (ES) is to analyze the cumulative environmental impacts of the Bureau of Land Management's geothermal leasing program and the China Lake Naval Weapons Center's (NWC) geothermal development program, and any other related actions.

All stages of geothermal development are considered that will result from the BLM leasing action. These include preliminary exploration, exploratory drilling, field development, electrical power generation and project close-out. Impacts from the NWC's geothermal program have been addressed in the NWC's Coso Programmatic FEIS, 1979[1]. These impacts will be addressed in this document as an accumulation of impacts from an interrelated project, (see Section 1.4).

A staged development is examined with an eventual combined electrical generation capacity of 600 MW for the field if Federal, state, and private actions described in Section 1.3 and analyzed in the ES are fully implemented. In addition, alternative uses of the geothermal resources are examined as possible scenarios in Chapter 7 of this ES. The specific time frames of analysis used in this ES are 1982, 1995, and 2030. It is assumed that exploratory drilling will commence in 1982; approximately 250 MW of electrical generation capacity will be installed by 1995. Although close-out of the field is considered in the ES, there is insufficient data to permit prediction of the physical limitations of the field and therefore the impacts are analyzed on the basis of cumulative impacts due to construction and operation of all generation stations without regard to those which may be shut down during the course of the program.

Alternatives to the proposed action are presented in Chapter 7 of this ES. The alternatives considered include:

1. No Action - Offer no leases. This is the "no action" alternative but assumes that the NWC geothermal program will continue.

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1 U.S. Navy, Naval Weapons Center, China Lake, "Final Environmental Impact Statement (FEIS) for the Navy Coso Geothermal Development Program", March, 1979, Naval Weapons Center, China Lake, California.

2. Leasing of all lands except those with significant surface conflict

3. Conduct partially deferred leasing in order to protect the cultural resources of the CGSA.

4. Lease with no surface disturbance on areas with sensitive resources.

5. Conduct a staged leasing program by area of decreasing geothermal potential.

6. Defer leasing until a comprehensive geotechnical testing program can be carried out under the supervision of an appropriate Federal agency.

7. Mandatory unitization of the development - In which all lessees would be required to enter into an agreement to operate the field by a single entity.

A number of alternatives were considered but not evaluated. These include:

Restrict areas of leasing to only those areas inside of the NWC. This was not considered realistic as the KGRA includes areas outside of the NWC boundaries, and there are noncompetitive lease applications in Rose Valley. There appeared to be no environmental benefit from this alternative.

Limit the number of lease sales. This alternative was dropped as there appeared to be no environmental benefit and is not necessarily consistent with current executive policy.

Lease under larger or smaller lease sizes than the normal 2,650 acres. Dropped as there appeared to be no environmental benefit for smaller lease sizes and larger sizes conflict with current statutes.

The proposed action is to lease the land for geothermal development for the primary purpose of generation of electrical energy. It is possible that it may be desirable to utilize some portion of the geothermal resource for non-electrical purposes. These might include:

Space Heating

Food Processing

Pisciculture

Ore processing

In the event that such non-electric utilization is proposed by a lessee, the environmental effects of such action would be evaluated by the Department of the Interior prior to approval.

1.1.1 Location and ES Area

The Federal lands proposed for leasing are located in Inyo County and cover 72,640 acres centered on public land and lands within the western side of the China Lake Naval Weapons Center (NWC) withdrawal north of Ridgecrest, California. Of the total, 28,160 acres are on public lands, and 41,560 acres are in the NWC withdrawal. Approximately 2,920 acres are NWC acquired lands within the proposed lease area, and are unavailable for leasing. Approximately 660 acres are privately held lands. The location of the proposed lease area is shown in Figure 1.1-1. Figure 1.1-2 at the end of this volume depicts the Coso Geothermal Study Area (CGSA) and the lands under consideration for leasing. The map shows the boundaries of the Known Geothermal Resource Area (KGRA) as currently defined by the USGS. The CGSA is smaller in size as certain areas of the KGRA were determined to be environmentally sensitive and less likely to contain an economic geothermal resource during the establishment of the scope of this ES.

1.1.2 KGRA History

The Coso area was designated as a KGRA in 1971, with acreage added to the KGRA in 1976 and 1978. However, the geothermal resource is not well characterized. The Department of Energy (DOE) has drilled a test well on NWC withdrawn land to initiate characterization of the reservoir. To date this well has not been successfully flow tested and, therefore, has provided little information. Other detailed surface studies have been conducted in the area to determine the characteristics; however, these data are insufficient to properly characterize the reservoir.

Non-competitive geothermal lease applications have been received by the Bureau of Land Management for parcels in the southwest corner of the ES study area. The lands applied for are included in this ES.

1.1.3 Agency Authorities and Roles

The Coso Hot Springs CGSA is located on public domain lands which are administered by the Bureau of Land Management, public domain lands which are withdrawn under PLO 431, 13 F.R. 22, for use by the Navy at the Naval Weapons

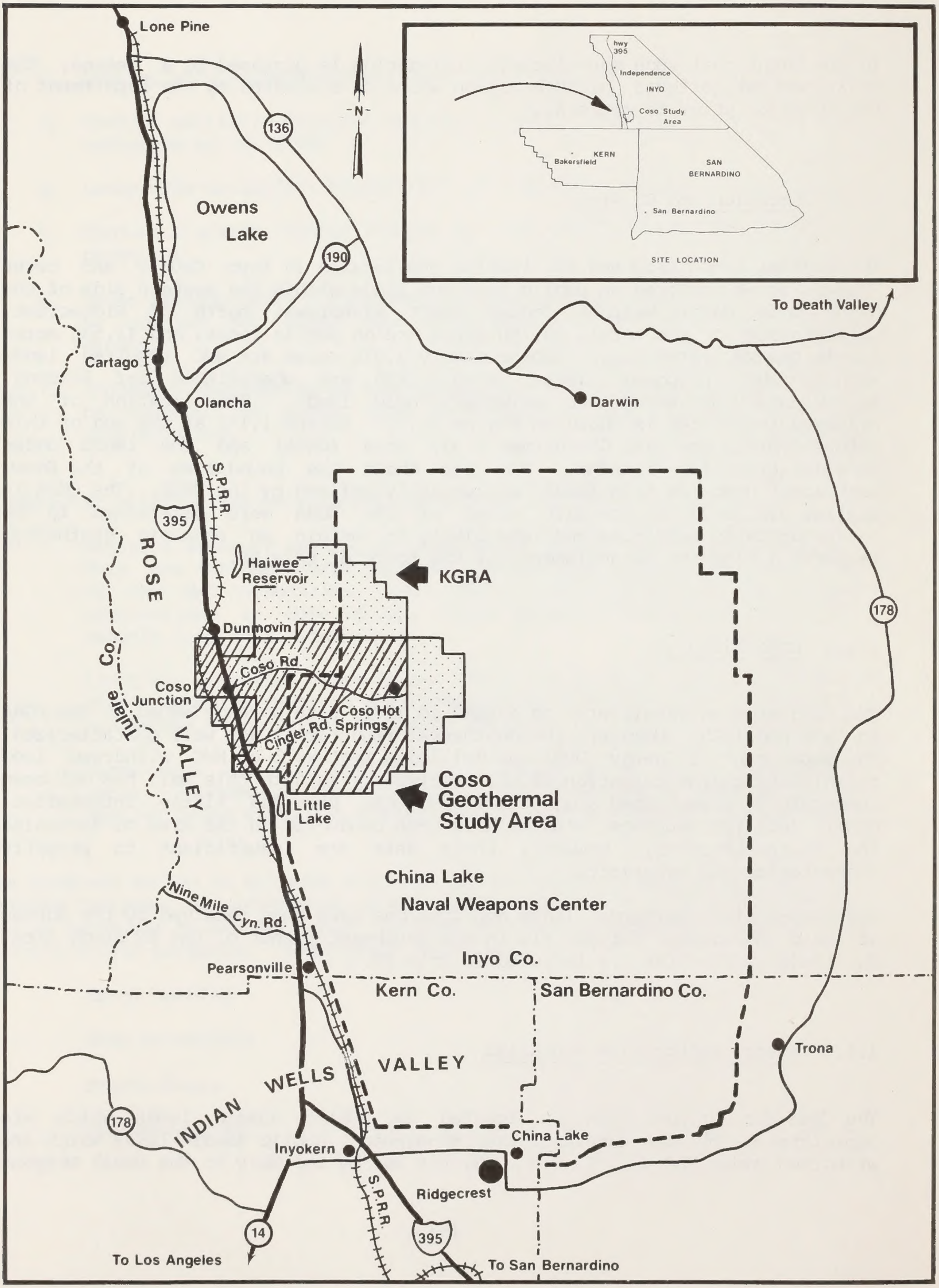

Figure 1.1-1. SITE LOCATION

Center (NWC), China Lake, California, lands which have been acquired by the Navy to consolidate its holdings at the Weapons Center, and private and state lands (see Figure 1.1-2 at the end of this volume).

Under the provisions of the Geothermal Steam Act, P.L. 91-581, 85 Stat. 1577, 30 U.S.C. Par 1002 et seq., the Secretary of the Interior is authorized to issue leases for the development and utilization of geothermal resources on lands administered by him -- including public, withdrawn and acquired lands -- under such rules and regulations as he may adopt consistent with the purposes of the Steam Act. With respect to the Coso Hot Springs KGRA, this authority extends to the public lands administered by the BLM and public lands withdrawn under PLO 431. Consistent with the provisions of the Engle Act, P.L. 85-377, 72 Stat. 27, 43 U.S.C. Pars. 155-158, geothermal leases for lands withdrawn for military purposes may only be issued by the Secretary of the Interior after determination by the Secretary of the Navy that such leasing is not inconsistent with the use for which the land was withdrawn. This Environmental Statement has been prepared, in part, to help in determining whether geothermal leasing is consistent with the purposes of this withdrawal.

The acquired lands within the NWC which are administered by the Navy are not presently available for leasing. However, pursuant to P.L. 95-356, Par. 603, 92 Stat. 585, 30 U.S.C. Par. 1002a, the Secretary of the Navy may enter into contracts for development of geothermal resources on real property under his jurisdiction (other than public lands administered by the Secretary of the Interior, i.e., the land withdrawn by PLO 431) and for the purchase of the energy produced under such contracts. The Navy has filed a phased ES describing the impacts which would result from development of the acquired lands within the Naval Weapons Center boundaries. The NWC phased ES is referenced with some frequency within this ES because of the interrelationships, the adjancency of the lands involved and the similarity of the environmental conditions.

The other legal restraint which may affect the issuance of leases on either the public lands or the withdrawn lands is Executive Order 6206 of July 16, 1933, which states that "lands . . . are hereby temporarily withdrawn from settlement, location, sale, or entry, subject to all valid existing rights, in aid of proposed legislation withdrawing the lands for the protection of the water supply of the City of Los Angeles." The lands under this withdrawal are located principally in the Rose Valley and the eastern slopes of the Coso Range. As noted previously, leases may be issued for these withdrawn lands, (see Geothermal Steam Act, Par. 3, 30 U.S.C. Par. 1002) so long as those leases are considered to insure adequate utilization of the lands for the purposes for which they were withdrawn. (See also Geothermal Steam Act, Par. 15(a), 30 U.S.C. 1014(a)). Since E.O. 6206 was for the protection of the water supply, any geothermal leases which may be issued may be subject to a condition that lease operations not impair the water supply. Depending on the operations proposed and the attendant need for water in those operations, such a condition could have a significant impact on the type and extent of geothermal development in the area. This ES will address the question of geothermal leasing and development in relation to the other resources in order to assist the Department in determining whether such leasing and development is consistent with E.O. 6206 and, if so, how it may be carried out to protect the water supply.

A detailed discussion of responsibilities of the DOI for the issuance and administration of geothermal leases may be found in the Final Environmental Statement For the Geothermal Leasing Program prepared by DOI and filed with the Council on Environmental Quality in 1973. Briefly, the DOI minerals management policy is to provide for and encourage orderly and timely development of minerals under its jurisdiction while requiring adequate measures to avoid, minimize, or correct both damage to the environment and hazards to the public health and safety.

1.1.3.1 Applicable Regulations

It is implicitly assummed throughout the description of the proposed action and in the analysis of the impacts that the applicable regulations will be enforced. These regulations include:

1. The USGS Geothermal Resource Operational Orders (GRO) which have been issued under the Geothermal Steam Act. These orders are:

    1. Exploratory Operations

    2. Drilling, Completion and Spacing of Geothermal Wells

    3. Plugging and Abandonment of Wells

    4. General Environmental Protection Requirements

    5. Plans of Operation, Permits, Reports, Records, and Forms (DRAFT)

    6. Pipelines and Surface Production Facilities

    7. Production and Royalty Measurement, Equipment, and Testing Procedures

2. 43 CFR 3200 - Establishes leasing terms and basis for royalty payments.

3. 30 CFR 270 - Establishes the authority of the USGS to regulate the development of geothermal resources on leased lands and to require compliance with lease terms and stipulations.

A comprehensive list of all the regulations and GRO's is provided in Appendix A of this ES. If the proposed leasing program is implemented, the USGS becomes the lead Federal Agency for all development activities. Prior to commencing operations upon the leased land for any purpose other than "casual use" and certain "exploration operations" as defined in 30 CFR 270.2(p) and (q), a lessee must obtain the joint approval of a plan of operation from the USGS and the appropriate land management agency. The USGS will also work with the U.S. Fish and Wildlife Service, the County of Inyo, certain State of California agencies, and all interested parties to receive advice and support. All drilling for the purposes of finding, testing, or producing geothermal resources is contingent upon an approved plan of operation. "Exploration operation" (including geophysical exploration) may be authorized in advance by the USGS in response to a lessee's Notice of Intent. To assist in the decision-making process regarding a lessee's proposed activities, the USGS prepares an Environmental Assessment (EA) which is site-specific and addresses potential impacts that should be avoided or mitigated. This procedure is repeated for each new proposed activity except that the surface management agency would be expected to have the lead regarding power generating facilities exclusive of research and demonstration facilities of 20 MW or more electrical capacity or net heat energy equivalent. A flow diagram of actions and regulatory overview required for each of the stages of geothermal development is shown in Figure 1.1-3.

A comprehensive listing of the various Federal, state, and local regulations which may apply to geothermal development is presented in Appendix A.

1.2 OBJECTIVE & NEED

The objective of the proposed leasing action is to make available the development and utilization of geothermal resources for the generation of electrical power. The geothermal resource is an attractive alternate to the use of fossil fuel resources for such generation.

The majority of the CGSA is located within the KGRA. However non-competitive lease applications for lands adjoining the KGRA have been received by the BLM. If the proposed action is implemented those areas will be leased on a non-competitive basis.

1.3 SPECIFIC PROPOSED ACTION

FLOW CHART OF CRITICAL PATH IN GEOTHERMAL EXPLORATION

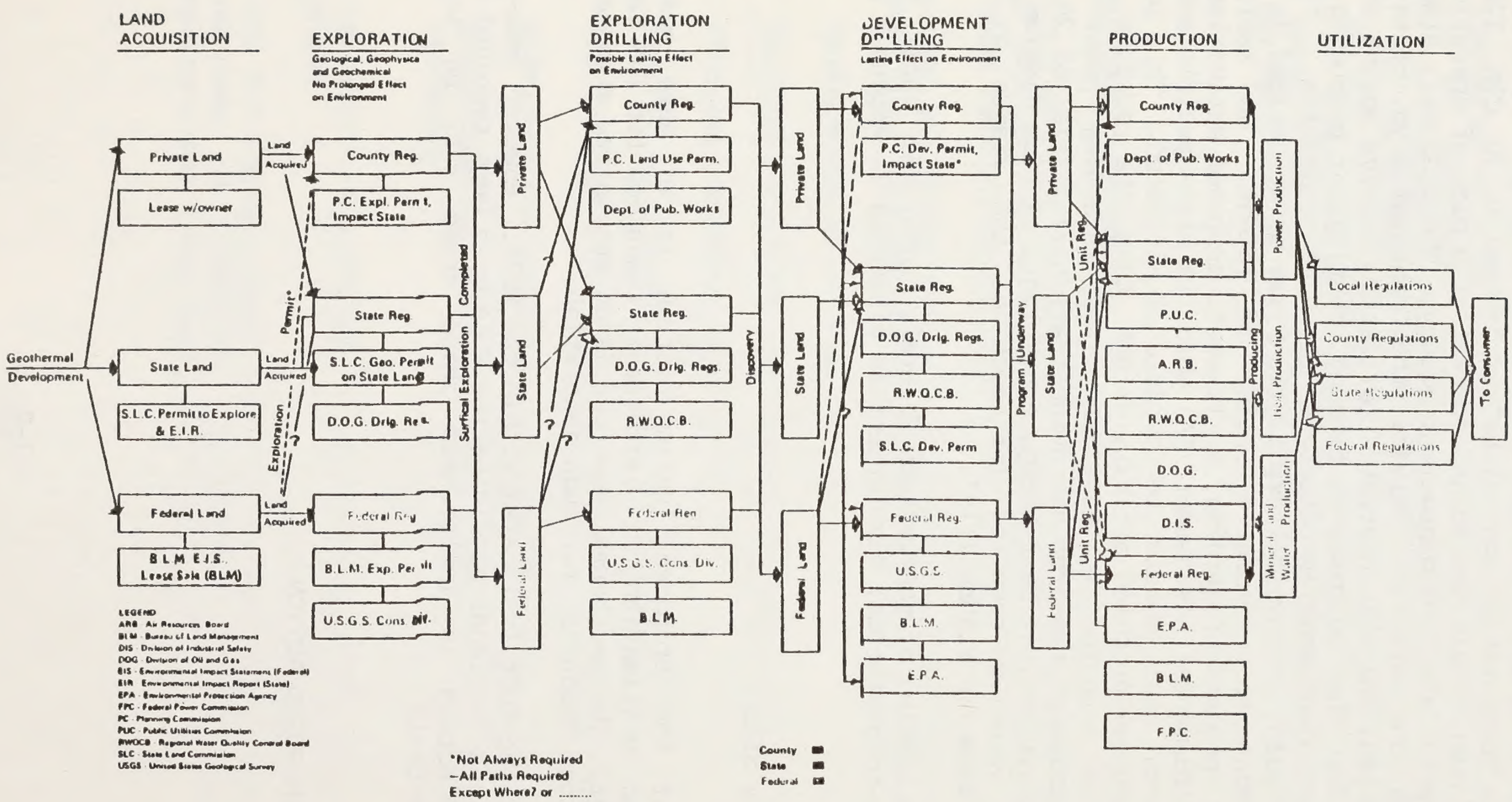

Figure 1.1-3

1.3.1 Stages of Geothermal Development

Based on the experience of other geothermal fields, the development can be broken into five stages:

1. Preliminary exploration - which involves the acquisition of geotechnical data. The methods used require non-intensive uses of the land. These include observations of surface features; application of geologic, geochemical and hydrologic techniques; and geophysical studies.

2. Exploratory well drilling - is the drilling of the first wells to evaluate the extent and physical characteristics of the geothermal resource.

3. Field development - during which sufficient wells to supply the required energy are drilled and power generation facilities are constructed.

4. Resources utilization - during which the resource is utilized to generate electric power. New wells may be drilled as old ones are depleted.

5. Close out - which occurs when a given area does not provide sufficient energy to maintain economic electric generation. This phase includes abandonment of wells and restoration of the area. Although it is considered, at the present time, to be a depletable resource, there is insufficient historic data to indicate what may be the true lifetime of a geothermal field.

Beginning with implementation of exploratory drilling and the addition of successive stages of development, several of these stages would likely be occurring concurrently on adjacent tracts of land.

1.3.2 Lease Size

The assumed lease tracts will each be 2,560 acres in size. This is the maximum size permitted by law. Lease tracts on NWC withdrawal lands will be jointly determined by BLM, USGS, and the NWC in accordance with the Memorandum of Understanding between the BLM and NWC signed in November 1977 (see Appendix C for text).

1.3.3 Geothermal Resource

Due to the fundamental data limitations discussed in Section 1.1, the description of the proposed action requires the utilization of a geothermal development model for the CGSA. This model employs the best estimates of experts (see foreword) as to the basic physical characteristics as well as the energy potential of the field. The model also includes a "most probable" scenario as to how the field will be developed in terms of the required facilities and the amount of surface disturbance due to development and operation activities. The geothermal development program proposed by the NWC for implementation on Naval acquired lands is also incorporated. The complete model is described in Appendix B of this ES. The reader is cautioned that the model represents the best estimates of various experts in the field. New geotechnical data and changes in technology, as well as new directions in regulatory policy, can all cause major deviations from the forecast.

Based on currently available data, the area can be described in terms of four zones of diminishing potential for economic geothermal development. These zones are:

> Zone 1 - High potential with average energy per well estimated to be 2.25 megawatt electrical.
>
> Zone 2 - Medium potential with average energy per well estimated to be 1.67 megawatt electrical.
>
> Zone 3 - Marginal potential, no estimate for energy per well can be made prior to development of zones 1 & 2.
>
> Zone 4 - Low potential, probably not useful for generation of electrical energy but may be useful for alternate uses of geothermal energy.

The four zones are shown in Figure 1.3-1. Zones 1 and 2 will provide sufficient geothermal energy to provide power for five 50 MW power plants plus the currently planned 10-15 MW plant on NWC acquired lands.

1.3.4 Time Staging

The development of the field will take place in an evolutionary manner. The geothermal development potential of the area is shown in Figure 1.3-2. Zone 1 is considered highest potential and Zone 3 lowest potential for the generation of electrical energy from geothermal fluids. Zone 4 is considered to be of such low potential within the present state of knowledge, that no projections as to its use for production of electrical energy are made at the time of writing this ES.

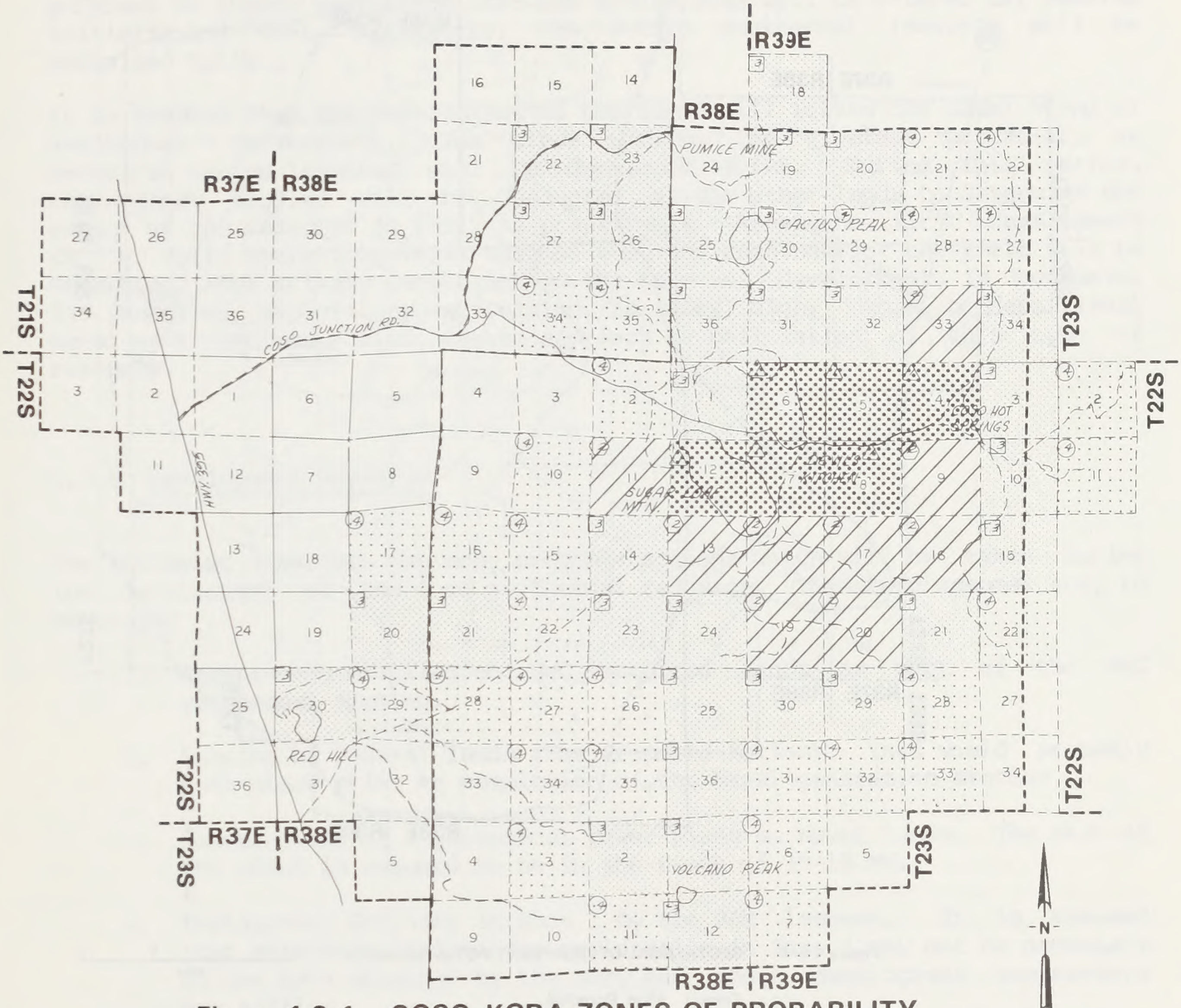

Figure 1.3-1 COSO KGRA ZONES OF PROBABILITY

1 High Probability
2 Moderate Probability
3 Low Probability
4 Uncertain
NWC Boundary

0 5
Miles

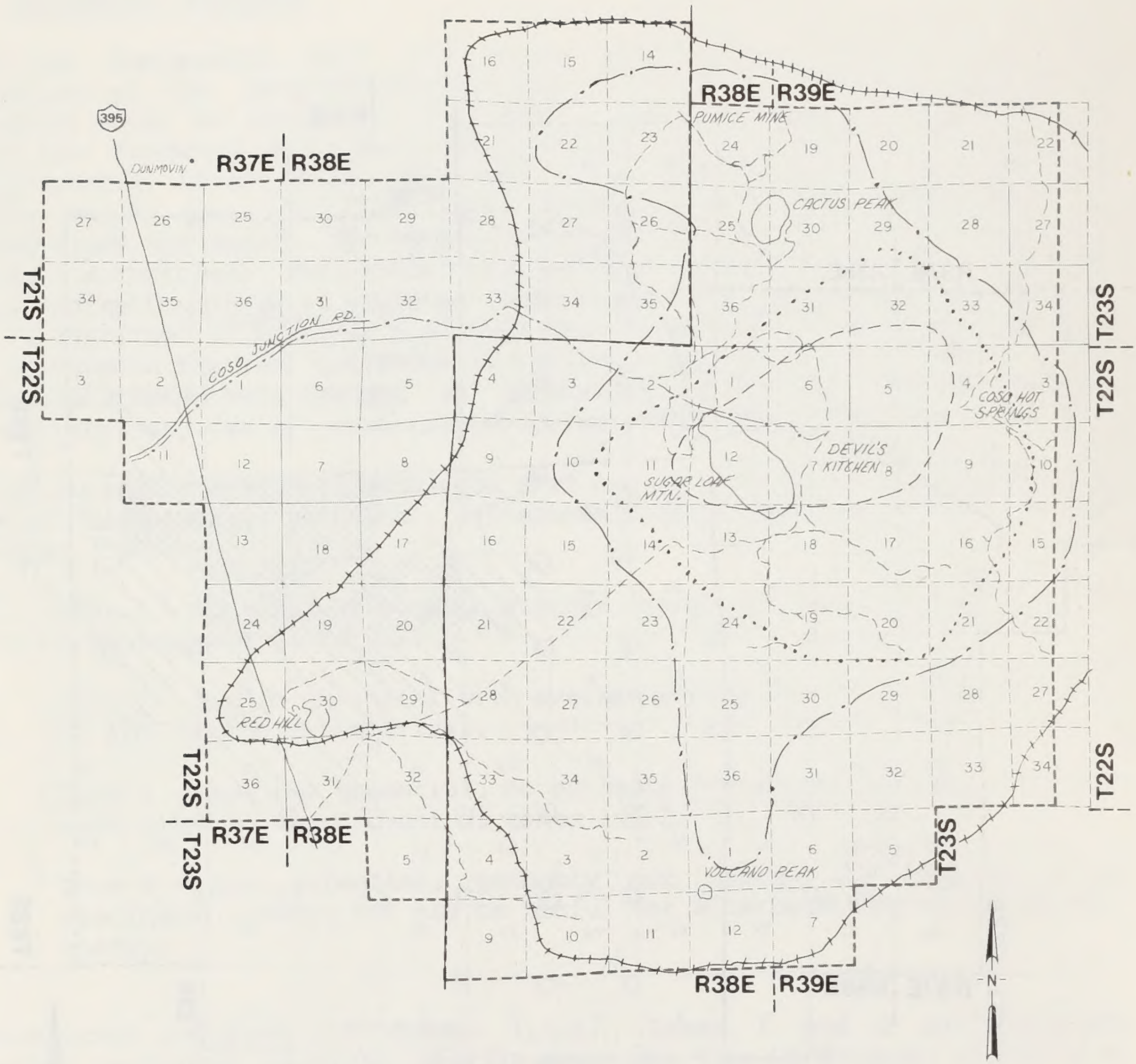

Figure 1.3-2 GEOTHERMAL DEVELOPMENT POTENTIAL AREA

Miles 0 1 2 3

- - - Zone 1 High Potential

····· Zone 2 Moderate Potential

—·—· Zone 3 Low Potential

+++ Zone 4 Uncertain Potential

—— NWC Boundary

No assumptions concerning the actual number of leases to be issued will be made in this ES since not all tracts offered may be bid upon by qualified bidders, or may result in acceptable bids. However, it is assumed for purposes of impact evaluation that the entire area will be offered for leasing initially and that, ultimately, the entire geothermal resource will be exploited fully.

It is assumed that the development of the field will follow the usual trend of geothermal development. The areas showing the greatest potential, as perceived by the lessees, will be developed first. During this period, exploratory studies will be conducted on the other lands to determine the extent of the resource as fully as practicable. After the first development is in full operation, it is assumed that the remainder of the field will be developed. The primary constraint on the rate of development is economic. The cost of exploratory activities is very high; thus, prudent fiscal management requires a slow, staged approach to utilization of this type of resource.

1.3.5 Development Scenario

The following describes the most probable actions which will be taken during the development of the Coso geothermal resource. The steps assumed are, in sequence:

1. Exploratory drilling on NWC acquired lands as part of the NWC geothermal program.

2. Leasing of Federal lands (The Proposed Action). This would probably take place prior to completion of the Naval generation station.

3. Construction of a geothermal power plant on Naval lands. The size of the plant is assumed to be in the range of 10-15 MW.

4. Exploratory drilling in Zone 1 by the BLM lessees. It is assumed that extensive preliminary exploration in Zone 1 may not be necessary as the data obtained by the Navy and their development contractors may suffice.

5. Construction of a 50 MW power plant on leased lands using geothermal fluids developed in Zone 1.

6. Exploration of Zone 2. This may include seismic studies, temperature gradient studies, as well as drilling of initial exploratory wells.

7. Construction of a 50 MW generation station on Navy acquired lands.

8. Construction of a second 50 MW generation station on leased lands in

Zone 1.

9. Construction of a 50 MW generation station using fluids developed from Zone 2.

10. Geological and hydrological exploration of Zones 3 & 4.

11. Construction of another 50 MW station in either Zone 1 or Zone 2.

12. Development of Zone 3 for a full field potential of 600 MW.

1.3.5.1 Preliminary Exploration

Although minimal exploratory operations are anticipated for Zone 1 prior to drilling, the other three zones will undoubtedly be explored in some detail. This section describes some of the types of exploratory activity which may take place in the zones to characterize the potential resource prior to drilling. Geologic, hydrologic, and geochemical techniques are used during this stage. These techniques require minimal ground disturbance. Normally only a four-wheel drive vehicle is required for entry. The simulation presented in Figure 1.3-3 shows a "typical" scene during this phase.

Microseismicity Measurement - This passive technique measures very weak earthquakes which may occur in geothermal anomalies. These earthquakes may indicate the presence of faulting and fracturing that could allow deep hot fluids to rise to shallow depths and form an accumulation of heat in available reservoir rocks. The method requires access to the land by vehicles.

Resistivity Measurement - This measurement technique determines the ability of the near surface rocks to conduct electrical currents. The effects of heat may change the conductivity of rocks within a geothermal area causing a change in the measured resistivity. The method requires direct access to the surface at two or more points. Normal procedure requires the use of a small four-wheel drive vehicle at each of the points.

Magnetic Measurements - Used to locate magnetic blanks or low spots in the local magnetic field. The magnetic properties of the rocks are destroyed at temperatures above 550°C (called the "Curie" point); thus, areas with low magnetic readings are indicative of a high temperature zone. Measurements can be taken from low flying aircraft or from the ground. Surface disturbance would be caused by vehicular traffic only.

Heat Flow Measurements - The measurements are used to define the areas of highest heat flow in relatively shallow (200' to 500') drill holes. A light, truck-mounted drilling rig is used to drill the holes; a water truck supplies the drilling fluid, and a pickup truck is used to carry the needed supplies.

Fig. 1.3-3 PRELIMINARY EXPLORATION STAGE GEOTHERMAL DEVELOPMENT MODEL

Passive and active types of exploratory activity will take place to characterize the potential resource prior to drilling. Some of this activity will require on-site exploration while aircraft may be used to accomplish other measurements. Surface disturbance would be caused by vehicular traffic only.

Simulated Features of Development Activity.

1. Unimproved access roads with low-use volume of traffic.

2. Temporary drilling sites with light, truck-mounted drilling rigs.

3. Ephemeral vehicular traffic. (Four-wheel drive pick-up and water truck).

1.3.5.2 Exploratory Well Drilling

Upon completion of the preliminary exploration, the only means of proving a geothermal resource is by exploratory well drilling. The steps involved for this activity are the same whether the hole is "exploratory" or is for a development well. A "typical" scene is shown in simulation in Figure 1.3-4. The steps required are:

1. Access road construction
2. Drill site (pad) construction including the mud sump
3. Drilling
4. Well testing
5. Waste disposal
6. Well venting or bleeding if necessary
7. Abandonment in the event the well is not productive or useful for power generation

The road to the site must be capable of allowing access to large trucks carrying the drilling rigs and other equipment; it is assumed that all roads will be 13.8 feet wide. Main roads will be surfaced with gravel or cinder. Site preparation requires clearing and leveling the land. If the site is on a slope, cut and fill operations must be undertaken. The mud sump must be lined with impervious material to insure that toxic substances do not seep into the ground. In addition, a reserve pit is required to accommodate excessive geothermal fluid which may emanate from the well during testing. This pit must be on the order of 150' by 150' by 10' deep.

Drilling, using required blowout prevention equipment, usually begins using drilling mud. When the increases in temperature and decreases in permeability indicate the need, a switch is made to compressed air. During the mud phase of the drilling, a pump circulates the mud and a shaker screen at the surface separates the rock cuttings to the waste sump, while allowing the drilling mud to pass through to the mixing tanks for recirculation. The cuttings and rock from the well are normally not considered to be toxic. The drilling mud, on the other hand, contains a number of additives, some of which may be considered hazardous. Depending on the actual chemicals used, disposition of the mud may require either a Class I or a Class II-I site. The nearest Class I site (at the time of preparation of this ES) is located in Covina, California; Class II-I sites are located near Elk Hills and Taft, California (approximately 160 miles distant).

When it is indicated that the drill bit is nearing the probable producing zone, air drilling is started. Air drilling has less tendency to clog or damage the steam-producing fractures as does mud drilling. During this phase

Fig. 1.3-4 EXPLORATORY DRILLING STAGE GEOTHERMAL DEVELOPMENT MODEL

The steps involved for exploratory drilling are the same as those needed for a development well.

<u>Simulated Features of Development Activity</u>.

1. Access road, 13.8 feet wide, surfaced with gravel or cinder.

2. Site preparation requiring clearing and leveling of land surface, and, in some cases, cut and fill operations.

3. Excavation of mud sumps and reserve pits (150' by 150' by 10' deep).

4. Drilling rigs and impedimenta.

5. Large truck vehicular traffic.

of the drilling, the returning air carries the rock cuttings and dust into the sump. The total amount of time required for well drilling is dependent on the depth of the well as well as on the type of rock encountered. However normal drilling to 5,000 feet takes from 6 to 8 weeks.

The well is then flow tested. As described in Appendix B, it is assumed that the Coso geothermal reservoir is liquid dominated and, therefore, the fluid from the well will have to be channeled into a reserve pit. For Zone 1 wells, it is assumed that the initial (test) flow will be at the rate of 250,000 lbs per hour. The duration of such tests will normally be approximately two days. At the above rate, approximately 154,000 cubic feet of water will discharge from the well. Including a reasonable safety factor, the reserve pit must, therefore, be capable of containing over 200,000 cubic feet of liquid. During this time, a portion of the fluid will vaporize (flash) and all of the non-condensible gases will escape to the atmosphere. The non-condensible gases include a mixture of carbon dioxide, hydrogen, carbon monoxide, and hydrogen sulfide. Approximately 25 lbs/hr of hydrogen sulfide are estimated to be emitted to the atmosphere during the duration of the tests.

1.3.5.3 Field Development

Development wells are drilled in the same manner as exploratory wells. The anticipated bottom hole spacing for these wells for the CGSA is estimated to be one well per 40 acres. However, it is anticipated that up to six wells can be located on a pad by using directional drilling methods; for purposes of estimating impacts, an average of four wells per pad will be utilized. Upon completion of a development well, it has been the practice to "bleed" the well continously, to insure that it does not clog. Depending on the time phasing of the construction plan, the output of the well may be directed into a reinjection well. The reserve pit must be sized to insure that there is sufficient capacity to hold geothermal fluid during the test phase and during the period of preparation of the associated reinjection well and its equipment. A representative plot plan for a geothermal plant showing wells and the plant is shown in Figure 1.3-5.

For the purpose of estimating the impacts of drilling, the following assumptions(3) are made:

1. Bottom hole well spacing will average one well per 40 acres.

2. To minimize the number of roads, pads, and sumps required, directional drilling from multi-well pads will be employed.

3. The percentages of the exploration wells drilled in Zones 1 & 2 which

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(3) A technical basis for the assumptions may be found in Appendix B - Geothermal Development Model.

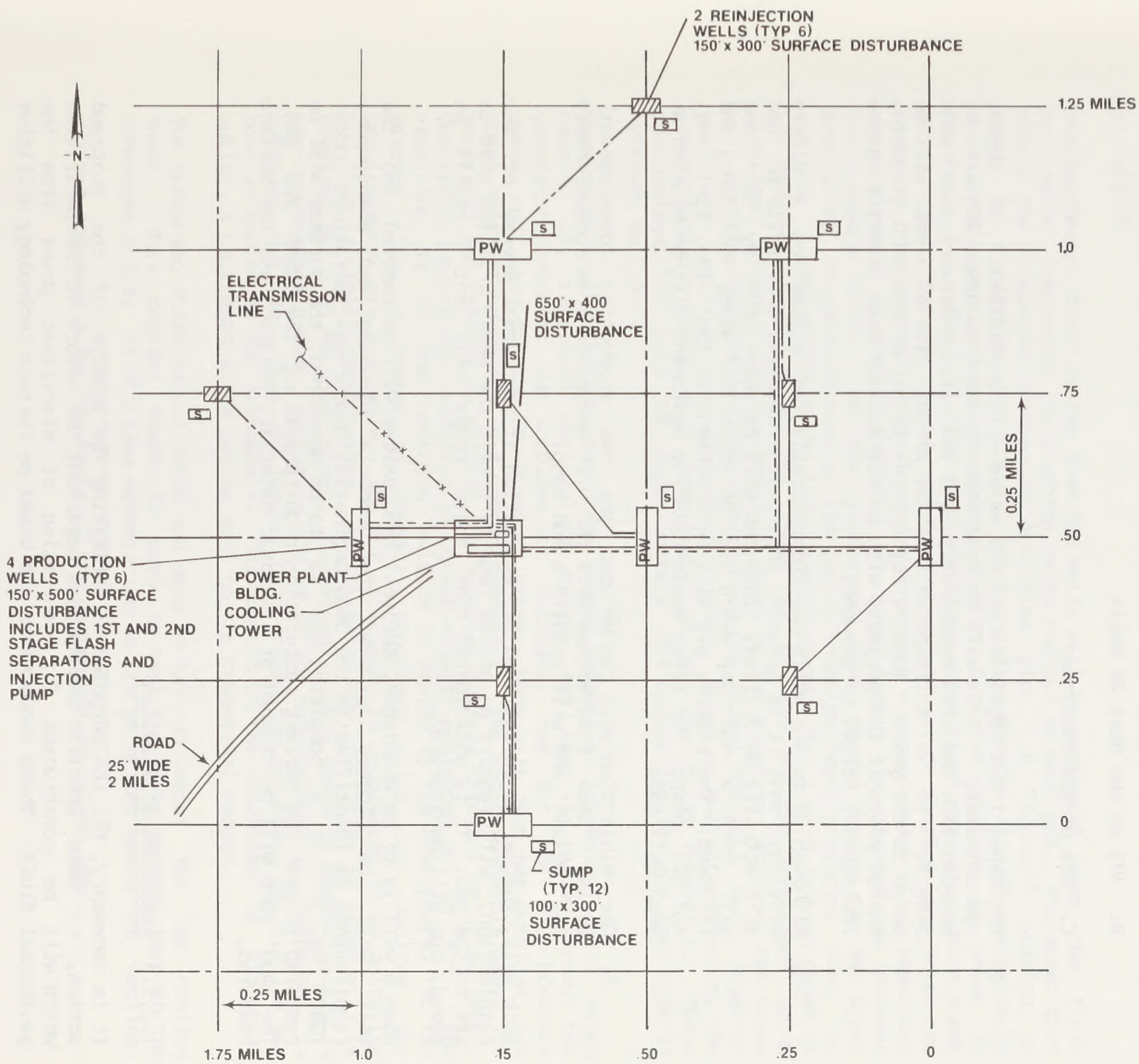

Figure 1.3-5 TYPICAL PLOT PLAN FOR FIELD DEVELOPMENT

will be successful development wells are:

A. 20% of the first 20 wells

B. 40% of the next 20 wells

C. 85% of the remainder

4. For Zones 1 & 2 approximately 600 wells will be drilled. Of these, approximately 120 will be less then 1500 meters deep, 180 will be between 1500 and 2000 meters deep, and 300 will be deeper than 2000 meters. It is anticipated that the average life of a well will be seven to ten years. Thus, a replacement factor of about 2.5 during the 30 years of the project, with an 85% success rate in drilling the replacement wells, is assumed.

5. Although up to six wells can theoretically be placed on a single drilling pad, it is assumed, that on the average, four wells per pad will actually be drilled. Each pad will be about 150' by 500' and will have a mud sump which will be about 100' wide, 300' long, and 15' deep. The reserve pit will be a minimum of 150' wide, 150' long, and 10' deep. The first stage flashing equipment will be mounted at each well pad.

6. One reinjection well can be used per two production (development) wells. Each reinjection well pad will occupy an area approximately 150' by 300' and will require a mud sump.

Each well, whether to be utilized for extraction of geothermal energy or for reinjection, will require an access road to permit the heavy drilling rigs to get to the pad. It is anticipated that these roads will not normally be paved, but will be graveled.

When a well is to be abandoned, the well head valves will be removed and the well will be plugged to meet the downhole plugging and abandonment requirements as identified in the USGS Geothermal Resources Operations Order (GRO) No. 3. If a complete pad is to be abandoned, the surface will be restored to meet the current restoration requirements of the USGS and BLM. The mud sump will be cleaned of all toxic material, covered, and the surface restored.

1.3.5.4 Resources Utilization

It is necessary, for the purposes of estimating the impacts of the proposed action, to make specific assumptions regarding the nature of the facilities which will be constructed for generation of electrical power from the geothermal fluid. These assumptions are based on current technology utilizing best engineering practice. The reader is cautioned that there may be significant improvements in the technology over the period of development. Such improvements would, in general, tend to reduce the degree of environmental disturbance, and therefore, the impacts described in Chapter 2 of this ES.

The geothermal fluid coming from the wells will be separated into the fluid and steam components by flashing units located at each pad. The steam then enters the generation station via insulated pipe. A "typical" station is shown in simulation in Figure 1.3-6. A flow diagram of such a station is shown in Figure 1.3-7 and the elevation plan for the station is shown in Figure 1.3-8. The well flow enters a first-stage flash separator where steam is separated from the liquid; also, some liquid may be flashed into steam by lowering the pressure. The liquid then enters a second-stage flash separator where pressure is lowered further and more liquid is flashed to produce low-pressure steam. As the geothermal fluid passes through the two flash separators, it gives up most of its useful enthalpy (work producing heat) in the form of high-pressure and low-pressure steam. The liquid is then piped to the reinjection well(s) and the steam is brought to the generator using insulated piping. At the point of entry to the generator station, the steam will contain some particulate matter which has passed the well head flashing units, as well as non-condensible gases. Based on current estimates, the non-condensible gases will constitute 1% of the total vapor(4). These non-condensibles will be approximately 99% carbon dioxide and less than 1% hydrogen sulfide.

Upon entry to the station, the steam passes through a "cleaning" unit which removes any remaining particulate matter and then is passed through the generator turbines. Two turbines are utilized, one for the high-pressure steam and one for the low-pressure steam. Upon exit from the turbines, the spent steam is condensed in a common condenser. The non-condensible gases are separated and treated to oxidize the hydrogen sulfide into sulfur or sulfates. The efficiency of the oxidation is conservatively estimated to be 95%; the remaining 5% of the hydrogen sulfide is vented to the atmosphere. At the present time, a number of chemical processes which can achieve the requirements are available; the 95% efficiency is considered to be quite low and thus is highly conservative. An estimated 800,000 lbs/hr of steam will be required for a 50 MW power plant. Contained in this steam is approximately 1% non-condensible gases; approximately 1% of the non-condensible component is hydrogen sulfide. Thus, 80 lbs per hour enters the scrubber, and 4.0 lbs per hour is vented to the atmosphere. The product of the oxidation is elemental sulfur, a byproduct which can be sold on the commercial market.

The condensed steam is collected and used as make-up water for the cooling tower. This cooling tower is used to cool the water passing through the condenser coils; it utilizes evaporation as the principal means of cooling.

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(4) See Appendix B for the basis of the concentration values used.

Fig. 1.3-6   FIELD DEVELOPMENT STAGE GEOTHERMAL DEVELOPMENT MODEL

In addition to field development, construction activities will also be short term visual features.

Simulated Features of Development and Construction Activity.

1. Access roads surfaced with gravel or impervious composition.
2. Development and reinjection wells. Well heads would replace drilling rigs. Each pad 150' by 500' or 150' by 300'.
3. Excavation and berms for mud sumps (100' by 300' by 15' deep) and reserve pits (150' by 150' by 10' deep).
4. First stage flashing equipment mounted at each pad.
5. Insulated steam pipes with expansion loops.
6. Cooling towers and turbine generator buildings.
7. Vehicular activity: scrapers, graders, backhoe, tractors, concrete mixers, air compressors, large trucks.

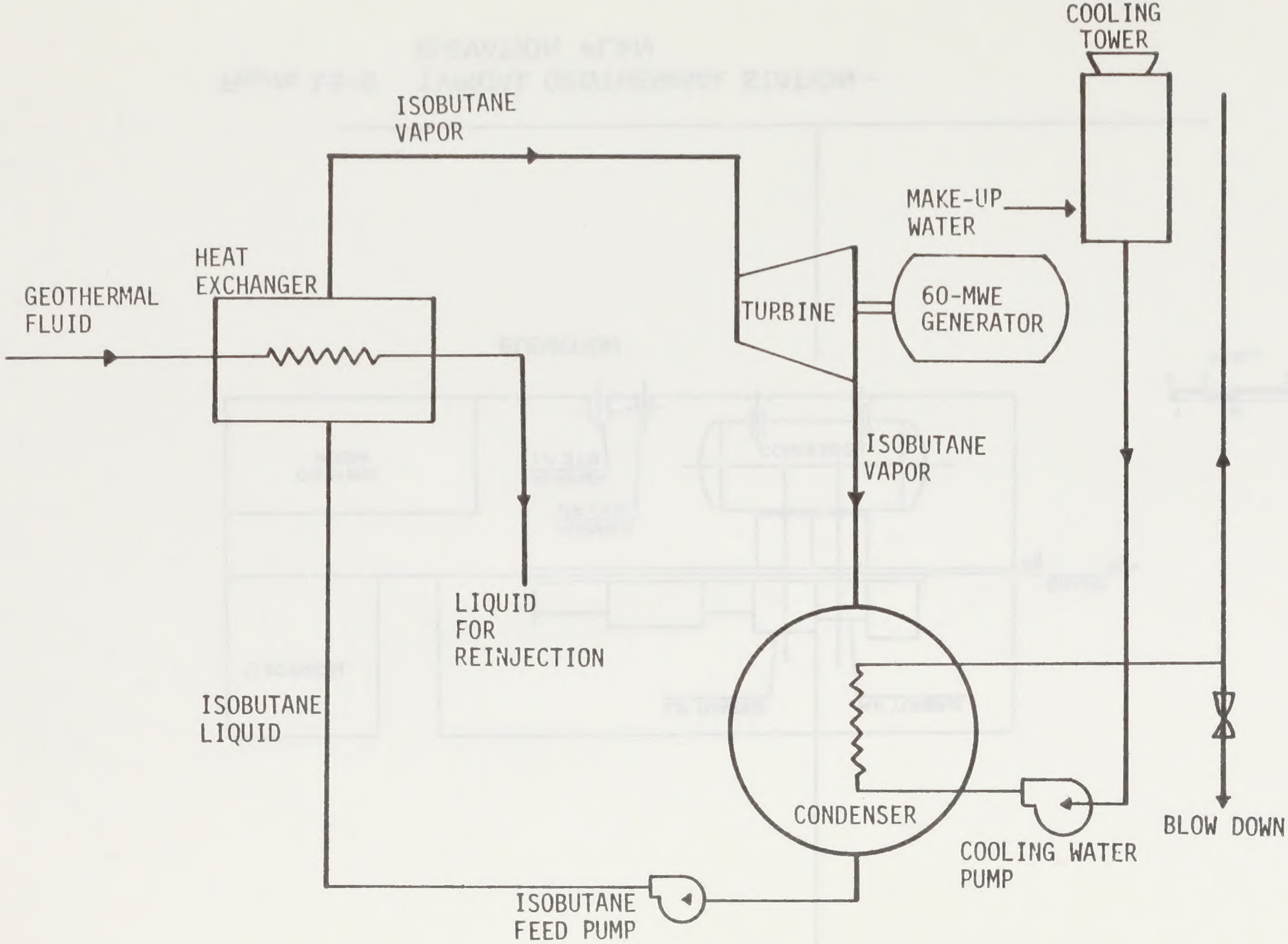

Figure 1.3-7. BRINE TO ISOBUTANE BINARY CYCLE

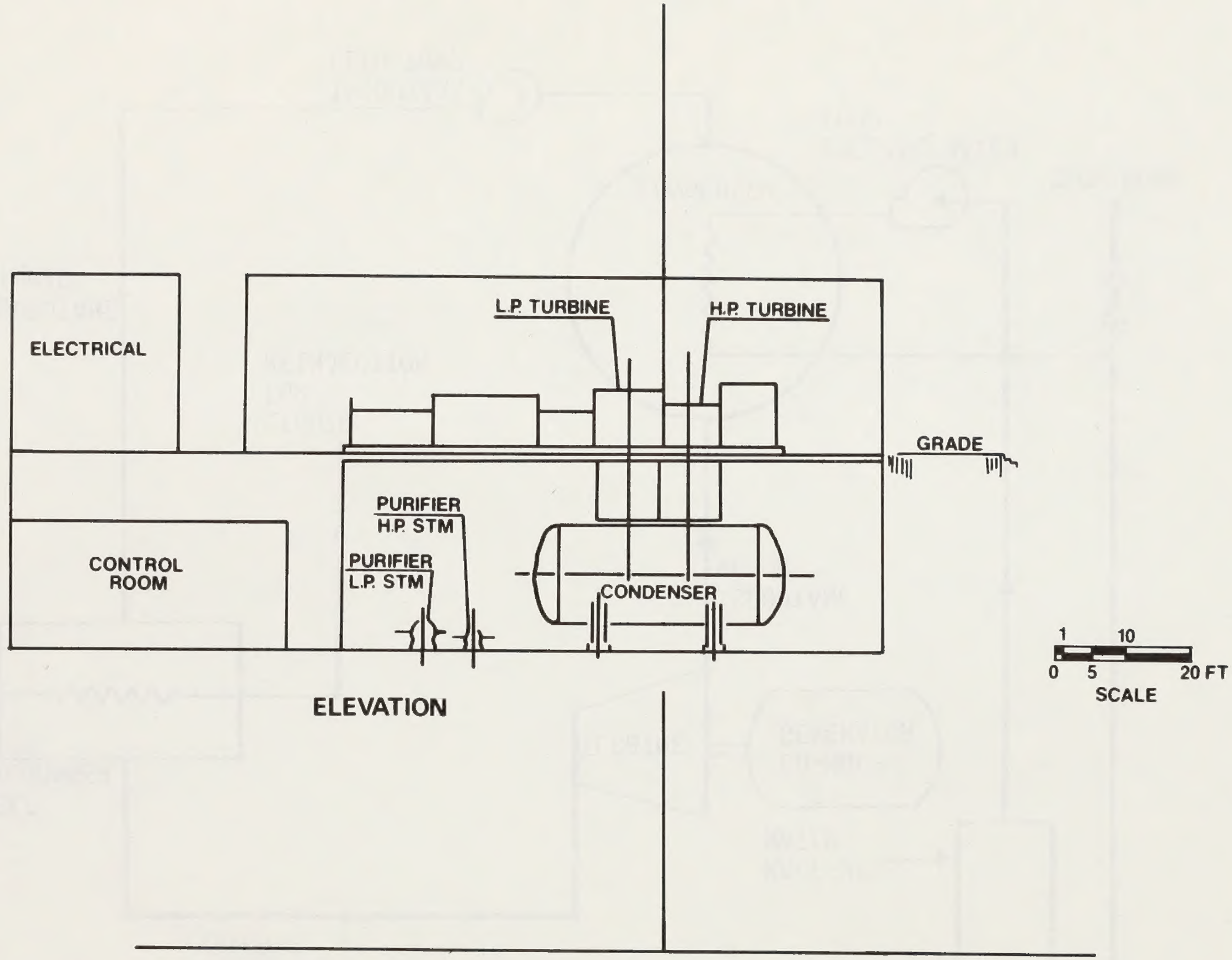

Figure 1.3-8 TYPICAL GEOTHERMAL STATION – ELEVATION PLAN

In addition to the water collected from the steam, approximately 200 gallons per minute of additional make-up water will be required by each power plant cooling system. The source of this water is discussed below.

All generation stations located on lands which are part of the NWC withdrawal will be required to have control rooms which are "hardened"(5). This insures that accidental impact during weapons tests will not cause irreversible damage to the plant. A typical layout of such a plant with the control room below ground and hardened is shown in Figure 1.3-9. The electrical power generated by the turbines is transformed in the electrical room and then is transmitted to the substation projected to be near the Coso Junction Road.

Transmission Lines - The power generated by each station will be brought to a common substation which will be located near the north-south running transmission lines east of Highway 395 near the Coso Junction Road. The most probable transmission line corridor is shown in Figure 1.3-11. At this point, the lines will connect with one of the available transmission lines owned by Southern California Edison Company or Los Angeles Department of Water and Power. The SCE transmission lines have the capacity to carry the projected power south, but not north from this point. It is anticipated that the transmission line towers will be constructed of steel using a design which minimizes visual intrusion to observers. An artists simulation of what such towers may look like is shown in Figure 1.3-10.

Water Utilization - It is assumed that the liquid fraction of the geothermal fluid will be reinjected into the reservoir, and that the vapor fraction of the fluid will be used consumptively for cooling purposes. Although the majority of the water used by the cooling towers will be derived from condensed steam, it is estimated that each 50 MW station will require an additional 323 acre-feet per year "make-up" water to meet the cooling requirements. It is assumed that this water will be supplied from wells drilled in the Rose Valley and brought to the various generation stations using a pipeline. The most likely route of this pipeline is shown in Figure 1.3-11. The pipeline will be 12 inches in diameter and pumps will be sized to permit transport of 4,000 acre feet per year. The pipeline will be constructed above ground. During the operation approximately 1 MW of electrical power will be consumed. A detailed description of the water requirements and water availability in the area is given in Appendix B of this ES.

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(5) By "hardening", it is meant that the facility is constructed in such a manner that it is impervious to accidental impacts.

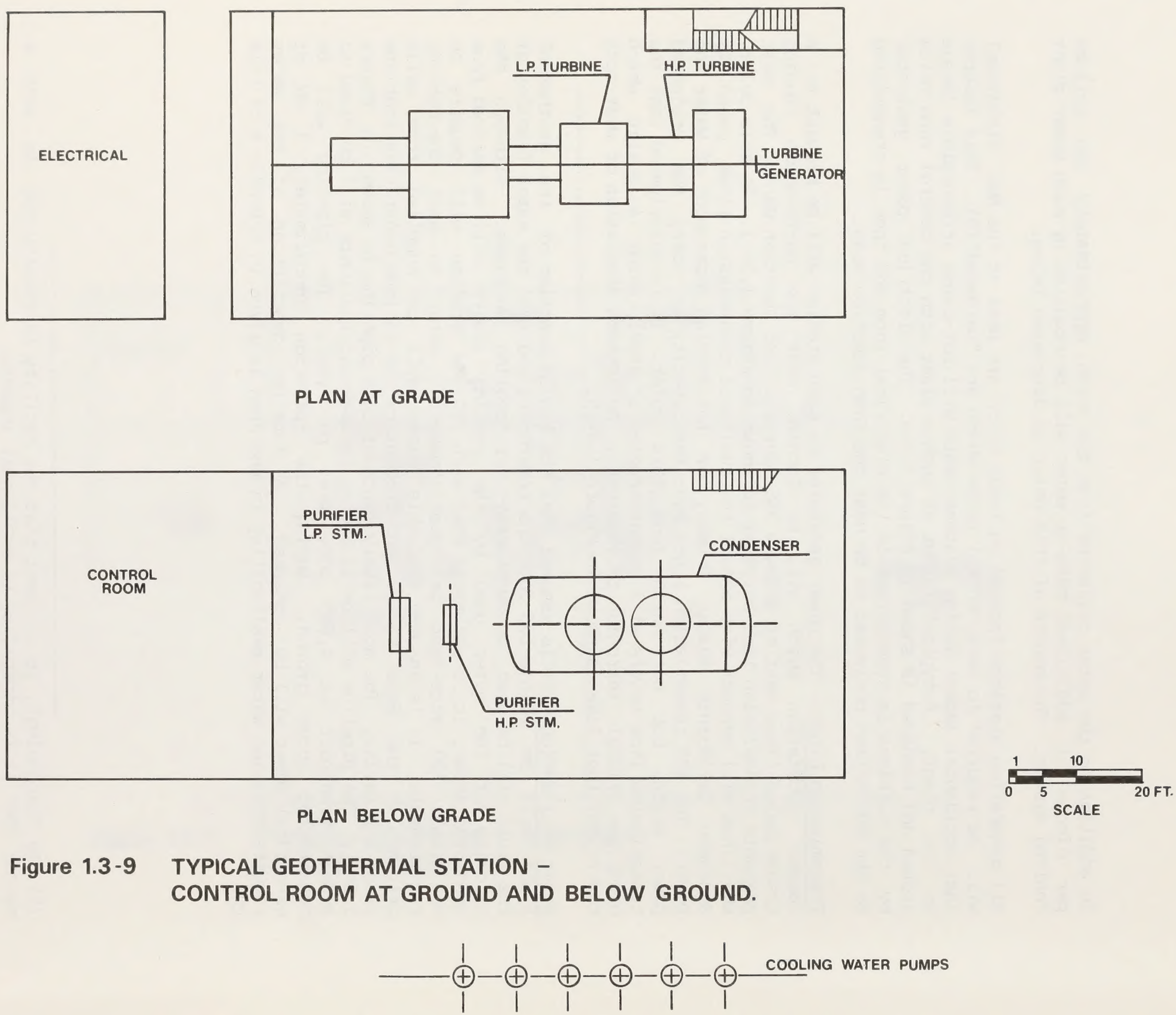


Figure 1.3-9 TYPICAL GEOTHERMAL STATION – CONTROL ROOM AT GROUND AND BELOW GROUND.

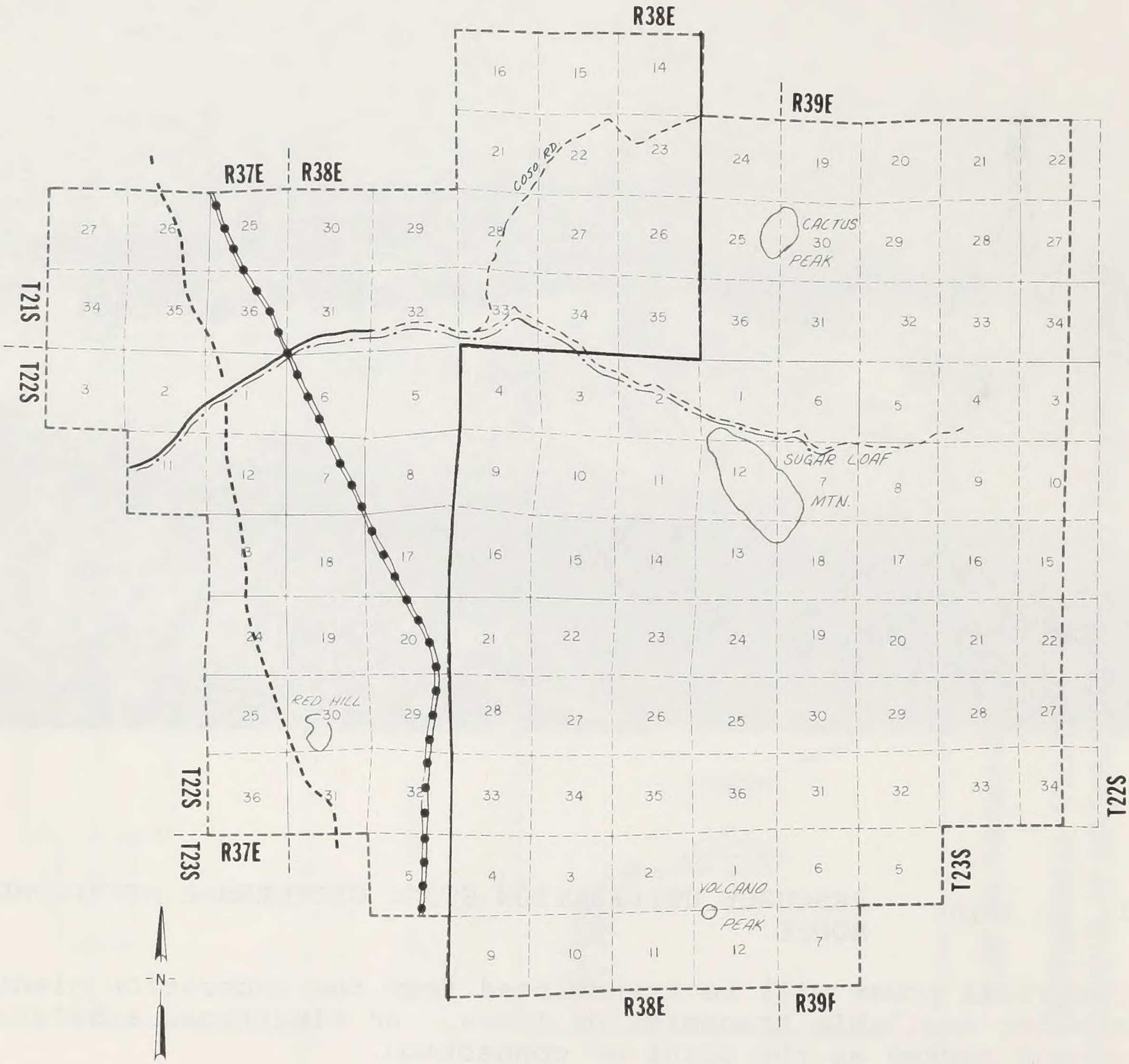
Fig. 1.3.10 RESOURCE UTILIZATION STAGE GEOTHERMAL DEVELOPMENT MODEL

Electrical power will be transmitted from the generation plant to the existing available transmission lines. An electrical substation will be constructed at the point of connection.

Simulated Features of Development Activity.

1. Transmission corridor including steel towers, electrical power lines, and maintenance road.

2. A common substation where power generated by each station will be transferred to a major north-south transmission lines.



0 1 2 3
Miles

Figure 1.3-11 **PROPOSED COSO WATER PIPELINE ROUTE AND EXISTING SCE, DWP TRANSMISSION LINES**

---- SCE 115 KVDC Transmission Line

●—●—● DWP 230 KVAC Transmission Line

NWC Boundary

–·–·– Proposed Coso Water Pipeline Route

1.3.5.5 Closeout

The estimated life of the field is unknown at this time. One major factor will be the amount of drawdown of the geothermal fluid. A 50 MW power generation station in Zone 1 will use approximately 2,300 acre-feet per year (750 million gallons). It is estimated that 600 acre-feet will be replaced annually by natural recharge, leaving an annual deficit of 1,700 acre-feet. This deficit will cause a drawdown of the geothermal fluid table in the reservoir of 17 to 45 feet per year, depending on the porosity and permeability of rock. In order to maintain the productive capacity of the field, this could be made up by injection of imported water. For the purposes of this ES, however, such injection will not be assumed as it is considered unrealistic in an area as arid and limited in water resources as is the CGSA. (See Appendix B for an analysis of water resources in the CGSA area.)

It is assumed that each well will have a productive lifetime of 7 to 10 years (experience in other geothermal developments), after which the well will be plugged and capped. New wells will be drilled in the vicinity of each generation station to replace the spent wells. When (and if) all wells in a given area are depleted, the generation station will be removed and the area will be restored following restoration requirements of the USGS and BLM, and the NWC within the withdrawal.

1.3.6 Noise

Significant noise emissions are associated with all aspects of drilling operations. During the mud drilling phase, the primary noise producers are the pumps and the drilling rig itself. The compressed air generator, used during the air drilling phase, is a major noise generator.

It is normal, current practice to mount a muffler on the air exit to reduce the noise from this source to "tolerable" levels. In addition to these elements, the other noise sources include heavy trucks making deliveries, the handling of the pipes, and the various pumps and generators required for the day-to-day operations. The primary noise source in the generating stations is due to the operation of the cooling towers. In addition, there is a significant amount of noise associated with construction of the power plants as well as with earth movement required for well pads and sumps. Representative noise levels near equipment which would be utilized are given in Table 1.3-1.

TABLE 1.3-1

TYPICAL NOISE LEVELS

Activity or Source	Distance Feet	Noise Level dB(A)
Drilling Rig	50	90-102
Jet Aircraft	200	120
Scraper, Grader	50	80-94
Backhoe	50	72-92
Tractor	50	76-96
Large Truck (diesel)	50	82-93
Concrete Mixer	50	75-88
Air Compressor	50	75-86
Jack Hammer	50	82-92
Air Drill	50	81-90
Rock Drill	50	85-95
Cooling Tower	10	85
Turbine/Generator (Enclosed)	25	70-75
50 MW Generator Facility	700	60-65

The values given in Table 1.3-1 are representative values derived from measurements taken at geothermal development sites. A detailed description of the projected noise environment is presented in Section 2.3.

1.3.7 Surface Disturbance

The amount of disturbed surface due to geothermal development will be highly dependent on the degree to which the USGS Geothermal Resource Operational Orders, special stipulations in leases, and regulations are followed; and on the proper management of the total resource(6). The estimates developed in Table 1.3-2 is based on the scenario described and represent average values. If drilling pad sites are required in rough terrain, the amount of disturbed

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(6) Management of the total resource can be accomplished by "unitization" of the field. By unitization it is meant that the field is operated by a single entity for the various lessees, with each participating in the proceeds according to a predetermined formula. This may be required by USGS if it is determined to be desirable for geothermal reservoir management.

land could be significantly greater than estimated here. This is due to increased length of access roads, increased amount of land exposed on the sides of hills for cut-and-fill operations, and increased disturbance due to pipeline access.

TABLE 1.3-2

ESTIMATED SURFACE DISTURBANCE
PER 50 MW GENERATION STATION

Facility	# Per Station	Disturbed Area Acres
Production Well Pads	6	10.3
Reinjection Well Pads	6	6.1
Mud Sumps	12	8.3
Reserve Pits	6	3.1
Power Plant	1	6.0
Access Road	2 miles	6.1
Maintenance Roads	14 miles	23.4
Unsuccessful Wells		
Including Sump & Pits	2	5.9
Transmission Line	1	2.0
Steam Pipelines	5 miles	6.06
Total Acres Disturbed per Station		74.26
1200 Replacement/Exploratory Wells (300) Pads		
Drill pads	300	510
Mud Sumps	600	420
Reserve Pits	300	150
Reinjection Wells	150	150
Access Roads	300	120
Total		1350
11 Operating Plants		800
NWC Plant		110
Total Disturbed Area for the life of the Project		2260

In addition to the above, there will be the surface disturbance caused by the transmission line from the Zone 1 area to the substation near Coso Junction as well as the substation itself. The 1200 replacement/exploratory wells indicated in Table 1.3-2 will be drilled over the lifetime of the project. As complete revegetation is unlikely in this desert environment, the total disturbed acreage considered is shown as the sum total of all of the wells drilled. The transmission line will require a maintenance road with estimated surface disturbance of 7.2 acres and the substation will occupy approximately 2 acres. The total amount of disturbed land, assuming a total of eleven 50 MW generation stations, would thus be approximately 825 acres of land. In addition, the generation stations which will be constructed by the Navy will cause the disturbance of approximately an additional 90-110 acres.

1.3.8 Costs and Employment

The costs of development of a geothermal resource appear to vary widely with geographic area and with the individual developer. If the field is not well characterized, exploration costs, exclusive of a test well, are on the order of $500,000 for a typical lease. Well drilling expenses are highly dependent on the depth of the well and on the local geology. Costs for a well have been estimated to be in the range of $0.5 million to $1.5 million. A typical well in the Geysers area is estimated to cost approximately $1.003 million (Glass, 1977). This figure does not include any costs due to problems which may be encountered during the drilling. A common problem encountered during drilling is the loss of a portion of the drill string in the well. If this occurs, it must be "fished" out or (if not removed) drilled around. Well fishing jobs are quite costly and can easily add up to $25,000 per incident. Other costly problems include lost circulation which can range from $10,000 to $20,000 for small problems up to $250,000 for major lost circulation incidents. Lost circulation means that the drilling mud does not return to the surface and implies that either the mud is being lost in porous rock or the drilling string has malfunctioned.

The cost of construction of a power plant of the type described is very difficult to estimate. Based on current costs in other areas, it is estimated that a 50 MW plant in the CGSA will cost $20-$30 million. Using the costs experienced in The Geysers area, the estimated cost of eight miles of transmission line from the power plants to the main substation near Coso Junction will be $11.5 million. In addition, the costs of transporting water will have to be added to the costs of the overall project. The cost of the water pipeline is estimated to be $2,500,000 which includes costs of the pipe, installation, and pumping equipment (LADWP, 1978).

Employment projections are based on projections made for similar projects in other geographical areas in the U.S. It should be noted that the constraints imposed by the NWC with respect to access and the requirement that the area be cleared during certain weapons tests may require more hours (and therefore more personnel hours) than would be the case for other areas. This is due to

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Glass, W.A., 1977, "Drilling Methods and Costs at the Geysers", Geothermal Resources Council, Transactions, Vol. 1, May, 1977.

the fact that all personnel must be cleared from the area when tests which may involve the area are conducted by the NWC. The NWC estimates that the area will have to be cleared on the average of 14 times per year. If the time lost is on the average of 4 hours each time the area is cleared, the increase in drilling costs could be as great as $15,000 per year per drilling crew. Projected employment without regard to NWC constraints is shown in Table 1.3-3.

TABLE 1.3-3
PROJECTED HUMAN RESOURCES REQUIREMENTS

Period	Employment	Average	Total
1980-83	Exploratory Drilling	50	
	Geotechnic Scientists	13	
	Road Crew	4	67
1984-85	Construction of 1 plant	145	
	Exploratory Drilling	110	
	Road Crew	4	
	Water Pipeline (avg.)	0.5	274
1986-90	Plant Operators	15	
	Exploratory Drilling	160	
	Road Crew	4	
	Workover Crew	25	
	Construction Crews	145	349
1991-95	Plant Operators	45	
	Exploratory Drilling	160	
	Road Crew	4	
	Construction Crews	145	
	Workover Crews	45	399
1996-2000	Plant Operators	75	
	Exploratory Drilling	210	
	Road Crew	4	
	Construction Crews	145	
	Workover Crews	45	479
2001-05	Plant Operators	105	
	Exploratory Drilling	210	
	Road Crew	4	
	Construction Crews	145	
	Workover Crews	45	509
2006-10	Plant Operators	135	
	Drilling Crews	160	
	Road Crew	4	
	Construction Crews	145	
	Workover Crews	65	509
2011-15	Plant Operators	165	
	Drilling Crews	110	
	Workover Crews	65	

	Road Crew	4	344
2016-20	Plant Operators	165	
	Road Crew	4	
	Drilling Crews	60	
	Workover Crews	90	319

1.3.9 Hazards

This section describes the environmental hazards associated with geothermal development as identified to date. The environmental impact of the occurrence of an incident due to a hazard is disscussed in Chapter 2 of this ES.

Over one-half of the area proposed for leasing is within the boundaries of the NWC withdrawal. The mission of the NWC is to be the principal research and development, test and evaluation center for air warfare systems (except anti-submarine warfare systems) and missile weapons systems and the national range/facility for parachute test and evaluation. The reservation is used for such testing. The probability of an accidental hit of a well head or generation station from a weapons test is low, yet it does constitute a real hazard. The consequences of an accidental hit from a weapons test are difficult to quantify. If the well head itself is struck, the most severe damage would occur due to uncontrolled discharge of the geothermal fluid. If a pipeline is struck, the degree of severity would be far less as the well could be rapidly shutdown. A hit on a generation station would have minimal environmental consequences as the design of these stations calls for "hardening". It should be noted that the danger to personnel associated with the geothermal development is essentially zero as no tests are permitted until the NWC range officer has determined that all personnel have either left the reservation or are in protective shelters.

A potential hazard associated with development of the Coso geothermal resources is well blowout. When this happens the geothermal fluid under pressure escapes to the surface in an uncontrolled manner. These uncontained fluids can cause severe damage to the environment, and ultimately to the viability of the resource itself. The Geothermal Unit of the California Division of Oil and Gas has identified five types of blowouts. Each of these is potentially capable of occurring if certain conditions are present or when drilling and completion practices are lax and not properly regulated. These types of blowouts are:

1. Punky Earth - A blowout occurs when steam or hot water under pressure is allowed access to the punky earth below the shoe of the well casing or surface pipe, and pressure is great enough to break through to the surface outside of the casing. Punky earth areas can be

recognized in the field and drilling in these areas will be avoided where possible.

2. Landslide - Causes rupture of the well below surface and escape of the geothermal fluid. The likelihood of an earthslide is very low; only one has been reported in the Geysers KGRA. These also can be recognized and avoided in most cases.

3. Improper Well-Head Completion(7) - Results in the escape of geothermal fluid at the casing interface. The probability of the occurrence of this type of hazard can be minimized by proper design, installation and supervision.

4. Inadequate Well-Head Bracing(7) - Caused by large internal pressure differentials which eventually crack and break off the casing below the landing flange. The probability of the occurrence of this type of hazard can be minimized by proper design.

5. Inadequate Casing(7) - Blowouts of this type occur when little or no surface casing is set and abnormally high, shallow reservoir pressures are encountered. The probability of the occurrence of this type of hazard can also be minimized by proper design.

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(7) GRO Order No. 2 requires that all wells be cased and cemented according to certain specifications, and that blowout preventers and related well control equipment be installed and tested immediately thereafter and maintained ready for use until drilling operations are completed. Therefore, the likelihood of a blowout occurring is very small if existing requirements are met and every unusual situation is handled promptly.

1.4 RELATED PROJECTS

This section describes activities in the geographic area which can contribute to the cumulative environmental impacts which may be ascribed to the development of the Coso geothermal resource. The projects described are logically grouped into two classes:

Energy production projects which influence the economic feasibility of geothermal energy development at Coso, or which can cause an accumulation of environmental impacts.

Those activities in the immediate area which are within the socio-economic sphere of influence of the Coso development.

1.4.1 Energy Related Projects

The proposed leasing of the Coso KGRA area suggests an eventual development of geothermal energy as a source of electrical power generation. Geothermal energy, as a power source, is a developing industry throughout California and therefore current status of the state's geothermal power should be reviewed.

The five major KGRA regions in California established by USGS are: the Geysers Region; the Eastern Sierra Region; the Northeastern Region; the Central Coast Region; and the Imperial Valley Region (Figure 1.4-1).

The Coso KGRA is within the Eastern Sierra Region. The Randsburg KGRA is directly south of Coso and is the closest proven Federal KGRA currently under lease sale. There are, to date, only 4500 acres available for leasing until the California Desert Plan has been implemented. The Mono-Long Valley KGRA, northwest of Coso, is also under consideration for leasing, pending completion of the Forest Service geothermal environmental assessment. These KGRA's, if developed for electric power generation, could help to satisfy the demand for electric power in Southern California if that electric power is wheeled south.

The Coso KGRA is partially located on the Naval Weapons Center (NWC) in China Lake. The NWC is developing a geothermal program on their fee acquired lands. The NWC plans to develop the resource through a contractor, while still retaining the rights to the geothermal resource. The program is based on an

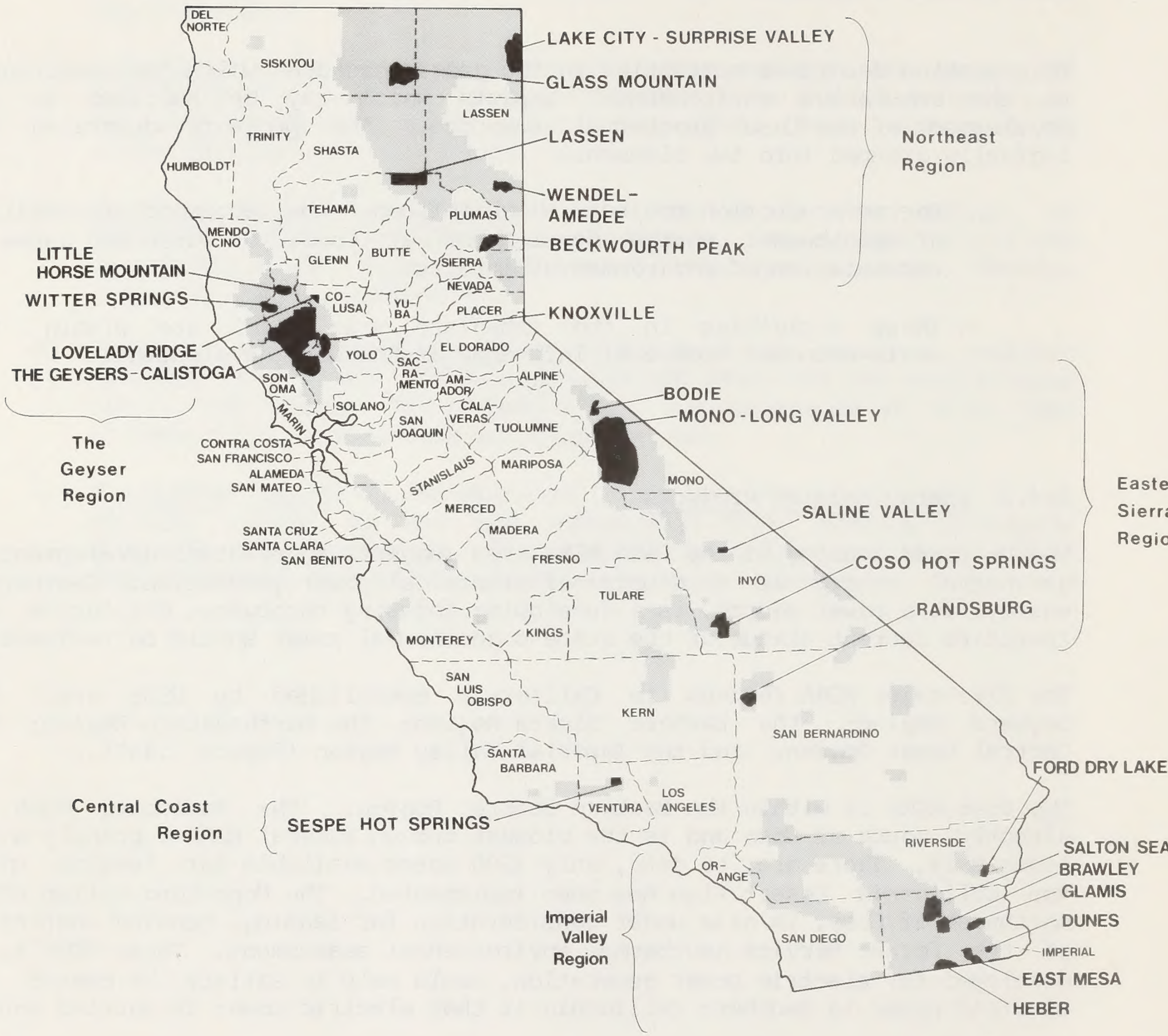

Figure 1.4-1 LOCATIONS OF CALIFORNIA KNOWN GEOTHERMAL RESOURCE AREAS (KGRA'S)

Federal KGRA's

Lands Valuable Prospectively For Geothermal Resources estimated total field potential of 300MW, with plans for an initial development of up to 110MW by 1985. The development of the Navy's program would not necessarily decrease the NWC's commercial electric power usage until their geothermal electric power generation has the capacity to support their power needs at all times. Until then, power required by NWC will have to be held in reserve as a back up supply by the area's operating utility.

While the Navy's development of geothermal energy will not change the immediate energy supply and demand ratio of the surrounding socio- economic area, it could, however, provide an accumulation of environmental as well as socio-economic impacts. Due to the simultaneous development of the resource by Federal lesses and the Navy, cumulative environmental impacts could be generated.

1.4.2 Related Projects in the Immediate Area

The mountain ranges which surround the Coso KGRA have historically been areas for various mining claims. In the Owens Lake area and throughout the Haiwee Reservoir area there are several uranium exploration projects to date. The Department of Energy (DOE), with the Bendix Company are exploring for uranium under the National Uranium Resource Evaluation (NURE) program. There are also several private energy mining companies currently drilling and evaluating in the area for this resource. The American Pumice Company owns seven pumice mines in the area, three of which they currently operate. To the west of the study area is the Renegade Mine which is under consideration for the mining of pozzolan. Within the study area itself is Red Hill, a cinder cone, which is expanding its present cinder mining operations. If these projects are developed, cumulative socioeconomic impacts may occur in the Indian Wells Valley after the development of the Coso KGRA. The City of Burbank is currently studying the feasibility of construction of a hybrid coal/geothermal power plant in the Rose Valley area. This study is still in the study phase and will undoubtedly be influenced by any development in the Coso lease area.

Haiwee Reservoir, northwest of the study area, is currently contained by two dams; one near the middle of the reservoir (northern dam) and a second at the southern end. The California State Division of Safety for Dams has performed a safety analysis on the South dam and has found it to be structurally unsafe under the maximum ground shaking which can be expected from an earthquake in the area. The southern half of the reservoir is to be emptied by September

20, 1982. At the present time, the Los Angeles Department of Water and Power, the owner of the dam, has not made a decision on whether to rebuild or alter the dam.

2.0 IMPACTS OF THE PROPOSED ACTION ON THE AFFECTED ENVIRONMENT

The material in this chapter describes the affected environment and the impact of the proposed action. The material is presented by resource area. This format has been selected as an attempt to provide continuity and ease of reading.

The Coso Geothermal Study Area (CGSA) is located in the southern California section of the Basin and Range Physiographic Province. The province extends from southern Oregon to the U.S. - Mexico border, generally characterized by isolated, roughly parallel mountain ranges separated by nearly level desert valley basins.

The CGSA is within a corridor of several north-south trending valleys, Owens, Rose, and Indian Wells--leading from the province center to its southwestern corner, the Mohave Desert. The study area roughly parallels Highway 395 and Rose Valley, with Dunmovin at the northern border, and Little Lake at the southern border. Its eastern border includes a portion the Naval Weapons Center China Lake Complex, paralleling the the western edge of the Coso Mountain Range.

The topography of the CGSA ranges in altitude from 2800' to 5950' above sea level. The terrain is uneven, mainly low to medium relief. The climate is harsh, arid and irregular with extremes of temperature and precipitation. This high desert steppe is within the Sierra Nevada rainshadow but receives more moisture than usual desert climates.

2.1 CLIMATE

2.1.1 Present Climatic Setting

The climate of the CGSA, typical of the southern California high desert region, is characterized by hot summers, cool to cold winters, large diurnal temperature ranges, low humidity, and little cloudiness or visibility restriction. The CGSA's latitudinal and continental positions are under the direct influence of the semi-permanent high-pressure cell located over the eastern Pacific Ocean. This high-pressure cell annually migrates north during summer, blocking the passage of cyclonic storms into the CGSA. During the winter season, the high-pressure cell migrates southward, permitting the cyclonic storms to move through the area.

Local topography in the CGSA is an important climatic factor. The Sierra Nevada Mountains to the west form a barrier to passing storms and frontal systems, and create a rainshadow effect over the CGSA. The air is warmed as it descends down the leeside of these mountains, and the potential for condensation is decreased. As a result, precipitation varies from 20 to 55 inches on the windward side of the Sierras to less than 10 inches annually in the vicinity of the CGSA. The north-south orientation of the mountains and valleys in the CGSA exert influence on the regional air flow pattern, creating south to southeasterly or north to northwesterly winds most of the year.

The average annual precipitation data for selected southern California stations shown in Figure 2.1.1-1 illustrate the effects of the Sierra Nevada mountains and the mountain ranges north and east of the Los Angeles metropolitan area. Based upon the local contours, the CGSA appears to have an average annual spatial precipitation range of 3 to 6.5 inches.

The Navy weather station at China Lake is the closest station to the CGSA which has long-term averaged precipitation data. The precipitation maxima at China Lake are greatest from November through April due to the southward migration of the eastern Pacific Ocean high pressure cell, permitting the movement of cyclonic storms and frontal systems across the region. From May through September, most of southern California remains dry with one exception. In the Mojave desert and the higher desert regions near the China Lake area, there is another rainfall maximum during the months of July, August, and September. This rainfall maximum is a result of convective activity, stemming from moisture flowing north and northwesterly from the Gulf of California. This convective activity is strongest in the south and east portions of the Mohave desert and decreases in strength heading towards the north and west desert areas.

Table 2.1.1-1 shows the greatest recorded 24-hour precipitation amounts for China Lake. Table 2.1.1-2 shows the mean number of days with precipitation inches. From Table 2.1.1-2, note that China Lake, the station closest to the CGSA, has at least one day per month per year (average) with precipitation $\geq$ 0.01 inches, except the month of June. All data in Tables 2.1.1-1 and 2.1.1-2 were taken from U.S. Naval Weapons Center Climatological Summmaries for 1946-1976.

No snowfall data for the CGSA were available for presentation. Therefore, average annual snowfall amounts (inches) were projected for seven stations with the CGSA using an Exponential Curve Fit program. Known average annual snowfall amounts (inches) and elevations (feet) of several southern California desert stations, together with elevations (feet) of the CGSA stations, were used to project snowfall amounts. The projected amounts for the CGSA are shown in Table 2.1.1-3. The snowfall amounts shown are a function of elevation, with no other factors included.

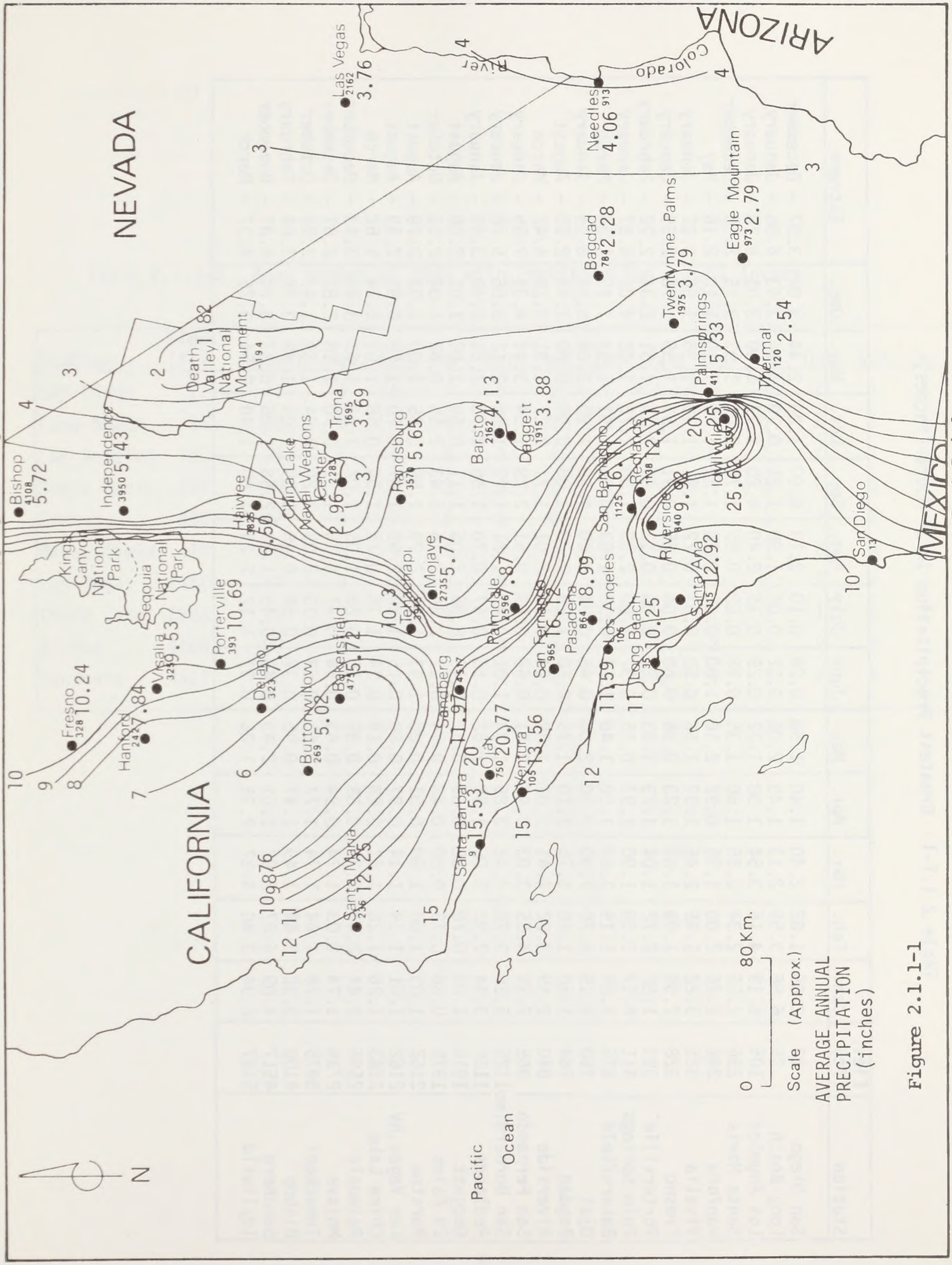
NEVADA
CALIFORNIA
ARIZONA
MEXICO
Pacific Ocean
N
Bishop 4108 5.72
Independence 3950 5.43
Haiwee 3825 6.50
China Lake Naval Weapons Center 2283 2.96
Trona 1695 3.69
Death Valley National Monument -194 1.82
Las Vegas 2162 3.76
Needles 913 4.06
Colorado River
Bagdad 784 2.28
Twentynine Palms 1975 3.79
Eagle Mountain 973 2.79
Palmsprings 411 5.33
Thermal 120 2.54
Barstow 2162 4.13
Daggett 1915 3.88
Randsburg 3570 5.65
Mojave 2735 5.77
Tehachapi 10.3
Palmdale 2596 7.87
San Bernardino 1125 16.41
Redlands 1138 12.71
Idyllwild 5397 25.62
Riverside 840 9.92
Santa Ana 115 12.92
San Diego 13 10
Fresno 328 10.24
Hanford 242 7.84
Visalia 325 9.53
Kings Canyon National Park
Sequoia National Park
Porterville 393 10.69
Delano 323 7.10
Buttonwillow 269 5.02
Bakersfield 475 5.72
Sandberg 4517 11.97
San Fernando 965 16.12
Pasadena 864 18.99
Los Angeles 106 11.59
Long Beach 35 10.25
Ojai 750 20.77
Ventura 105 13.56
Santa Barbara 9 15.53
Santa Maria 236 12.25
0 80Km.
Scale (Approx.)
AVERAGE ANNUAL PRECIPITATION (inches)

Figure 2.1.1-1

Table 2.1.1-1 Greatest Precipitation in 24 Hours (inches)

Station	Elev. (ft)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Extreme
San Diego	13	2.65	1.82	2.40	1.40	1.50	0.28	0.10	2.13	0.90	1.20	2.44	3.07	3.07 - December
Long Beach	35	6.86	3.59	2.13	1.49	2.06	0.52	0.04	1.90	1.21	0.70	3.14	3.43	6.86 - January
Los Angeles	105	6.19	4.16	3.54	1.88	1.72	0.29	0.15	2.40	4.20	1.77	5.60	3.01	6.19 - January
Santa Maria	236	2.55	2.34	2.55	1.60	1.35	0.26	0.62	0.85	1.78	2.07	1.93	3.15	3.15 - December
Hanford	242	1.26	2.00	1.55	0.92	2.16	1.00	0.08	0.28	1.22	1.20	1.10	1.10	2.16 - May
Visalia	325	3.22	1.45	2.45	1.37	1.56	0.50	0.03	0.22	1.81	1.30	1.36	1.50	3.22 - January
Fresno	328	2.59	1.99	1.63	1.23	0.96	0.60	0.04	0.25	0.91	1.55	1.35	1.76	2.59 - January
Porterville	393	1.82	2.72	1.04	1.23	1.83	0.24	0.08	0.13	0.69	2.13	1.61	2.34	2.72 - February
Palm Springs	411	4.57	2.30	1.90	1.97	0.55	0.37	2.80	2.03	1.80	2.75	1.62	4.02	4.57 - January
Bakersfield	475	1.09	1.19	1.68	1.00	1.40	1.10	0.30	1.03	0.56	1.51	1.54	1.15	1.68 - March
Ojai	750	8.15	5.70	7.90	3.30	2.00	0.48	0.24	0.60	4.10	1.95	3.85	5.15	8.14 - January
Bagdad	784	1.50	1.20	1.75	1.10	1.75	0.50	1.29	2.20	1.00	2.00	0.80	1.48	2.20 - August
Riverside	840	2.59	3.22	4.41	3.07	1.39	0.24	0.10	2.01	1.71	2.27	1.31	3.28	4.42 - March
San Fernando	965	7.55	4.55	3.03	2.92	2.51	0.68	0.59	0.51	2.29	1.59	3.43	4.31	7.55 - January
San Bernardino	1125	5.29	3.78	4.46	3.85	1.24	1.02	0.42	1.21	1.72	1.68	2.12	3.86	5.28 - January
Redlands	1138	3.44	2.93	3.08	1.98	1.62	0.55	0.57	0.70	1.55	2.78	1.55	2.49	3.44 - January
Daggett	1915	1.03	0.70	0.88	0.65	0.37	0.45	0.96	2.06	1.11	0.66	1.08	1.01	2.06 - August
29 Palms	1975	0.88	0.73	0.80	0.48	0.34	0.11	2.34	2.16	1.43	2.55	0.82	1.08	2.55 - October
Barstow	2162	1.03	1.00	1.50	0.61	0.80	1.93	1.35	2.79	1.50	0.85	2.00	2.07	2.79 - August
Las Vegas,NV	2162	1.01	1.19	1.14	0.97	0.80	0.75	1.32	2.59	1.07	0.70	1.78	0.95	2.59 - August
China Lake	2283	1.26	1.28	1.62	0.88	0.19	0.29	1.35	0.75	1.54	0.58	1.03	1.14	1.62 - March
Palmdale	2596	2.44	2.43	2.39	0.88	0.35	0.15	0.28	1.05	1.02	1.63	1.63	3.43	3.43 - December
Mojave	2735	1.74	2.03	1.74	0.94	0.43	0.54	0.47	0.76	1.31	0.70	1.18	2.81	2.81 - December
Tehachapi	3975	1.78	1.64	1.74	1.77	0.63	0.63	0.30	2.03	2.20	2.84	1.89	1.47	2.84 - October
Bishop	4108	3.32	3.64	1.49	1.47	0.95	0.32	0.86	0.46	0.59	1.05	1.79	3.35	3.64 - February
Sandberg	4517	4.09	4.87	2.97	2.01	2.43	0.49	0.49	1.83	2.68	1.86	6.87	3.74	6.87 - November
Idyllwild	5397	2.94	3.40	4.37	2.35	1.26	0.37	1.12	2.23	1.80	1.40	2.54	3.26	4.37 - March

Table 2.1.1-2 Mean Number of Days with Precipitation ≥ 0.01 Inches

Station	Elev. (ft)	Annual	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
San Diego	13	41	6	6	7	5	2	1	<½	<½	1	2	5	6
Long Beach	35	30	5	4	4	3	1	<½	<½	<½	1	2	3	5
Los Angeles	105	35	6	6	5	3	1	1	1	<½	1	2	3	5
Santa Maria	236	45	7	7	7	5	2	1	<½	<½	1	2	5	7
Fresno	328	42	8	7	6	5	2	1	<½	<½	1	2	5	7
Bakersfield	475	36	5	6	6	4	2	<½	<½	<½	1	2	3	5
Las Vegas	2162	24	3	2	2	2	1	1	3	3	2	2	2	2
China Lake	2283	15	2	2	1	1	1	<1	1	1	1	1	2	2
Bishop	4108	29	4	3	3	3	3	2	2	2	2	2	2	3
Sandberg	4517	40	6	6	6	4	2	<½	<½	1	1	2	4	6

Table 2.1.1-3 Data Points Used in the Exponential Curve Fit Equation for Projecting Snowfall Amounts in the CGRA

Southern California Desert Stations	Actual Elev. (feet)	Reduced Elev. (x) (feet)	Average Annual (y) Snowfall (inches)
Tehachapi	3975	2060	29.5
Sandberg	4517	2602	28.5
Bishop	4108	2193	8.6
Palmdale	2596	681	2.9
Mojave	2735	820	1.9
Las Vegas	2162	247	1.4
Twentynine Palms	1975	60	1.1
Daggett	1915	0	0.9
China Lake	2283	368	Trace (0.1)

The exponential curve fit program used the equation: $\ln y = \ln a + bx$, where (x) equals the station elevation in feet and (y) equals the average annual snowfall in inches. The station elevations are reduced so that the lowest station elevation equals zero, and the data points better fit the curve. The program computations were as follows:

$$a = 0.57, \; b = 1.51 \times 10^{-3}$$

$$\ln y = \ln(0.57) + 1.51 \times 10^{-3}(x)$$

$$y = 0.57e^{1.51 \times 10^{-3}(x)}$$

Correlation coefficient (r) = 0.84

Temperature within the CGSA may vary up to 15°F as a direct result of differences in elevation. Assuming an atmospheric lapse rate of 5.4°F/1,000 feet, the temperature at Cactus Flats (5,000 feet) would be almost 15°F cooler than the temperature at China Lake (2,283 feet) (see Table 2.1.1-4).

The mean annual temperature at the Naval Weapons Center weather station at China Lake is 64.0°F. Monthly normals range from 43.1°F in January to 86.2°F in July. The daily temperature extremes show a normal daily minimum in January of 28.7°F while the normal daily maximum is 102.3°F in July. Temperature normals and extremes for China Lake are presented in Table 2.1.1-5. Table 2.1.1-6 shows the monthly temperature extremes, °F, for the CGSA and surrounding high desert region (including Las Vegas, Nevada) for The period August 1977 through September 1978. The California data were reported by NWC personnel, and the Nevada data by the National Weather Service. It is difficult to discover patterns due to incompleteness of the data. but the table does reveal the large temperature ranges between the monthly maximum and minimum temperatures, with some differences of 60°F to 70°F.

Based upon long-term data from weather stations at several locations in the Mohave Desert, it can be estimated that the 50 percent probability date of the last spring frost is around April 1.

Typical of most desert areas, the relative humidity in the Coso CGSA is quite low. The mean monthly RH values at China Lake range from 23 percent in July to 52 percent in December. There is an average of 74 days (20.3 percent) per year of total cloud cover, with a maximum number of cloudy days per month during the winter season and a maximum number of clear days per month during the summer and early fall seasons.

Prevailing winds in the CGSA are from the south-southeast or north-northwest at all times of the year. Wind data were collected in the Coso area by the Navy for one year during 1977 and 1978, and a sample monthly average wind rose for August 1978 is shown in Figure 2.1.1-2. Long-term data show the annual average wind speed at China Lake to be 8.2 miles per hour, with the highest monthly average (10.4 mph) occurring in May. There are occasional high winds from the north and from the west, the strongest gust ever recorded at China Lake being 81 mph in March 1952. (See the Air Quality Technical Report.)

2.1.2 Impacts of the Proposed Action on Climate

Any effects of geothermal development upon climate will be localized and should not affect regional patterns. The only potential impacts of any significance should be upon microclimatic variables, and can be expected to occur largely within the study area.

Local temperature patterns will change by several degrees due to waste heat emitted from the power plants, particularly from the cooling towers. There

Table 2.1.1-4 CGSA Daily Temperature Comparisons
1. Daily Maximum Temperature
2. Daily Minimum Temperature
3. Daily Hourly Average Temperature

Date		Airport Lake (2300)	Little Lake (3180)	Rose Valley Ranch(3435)	Coso Basin (3560)	Red Hill (3600)	Haiwee (3820)	Cactus Flats (5000)
8-11-78	1.	104	98	97	98	99	96	92
	2.	72	72	63	72	70	73	66
	3.	87.0	84.3	78.5	84.3	82.3	82.9	78.8
8-12-78	1.	104	98	92	99	100	96	86
	2.	62	62	53	60	68	67	54
	3	83.9	82.1	76.9	79.8	82.7	80.9	71.7
8-13-78	1.	97	93	90	92	92	91	84
	2.	59	68	54	57	68	62	48
	3.	78.6	81.9	76.5	75.3	80.4	79.2	68.1
8-14-78	1.	95	91	90	91	92	89	84
	2.	51	62	49	53	67	63	53
	3.	75.3	76.7	69.5	76.5	77.2	74.9	69.2
8-25-78	1.	94	88	87	89	90	86	81
	2.	41	46	39	40	53	53	34
	3.	70.5	70.5	64.2	66.9	72.3	71.0	60.5
8-26-78	1.	96	90	89	91	93	90	83
	2.	44	52	46	44	52	54	39
	3.	72.2	72.2	68.6	68.9	74.0	74.1	63.7
8-27-78	1.	99	94	94	94	95	95	89
	2.	47	58	52	51	57	62	49
	3.	74.5	77.4	72.2	73.2	77.4	76.4	70.7
8-30-78	1.	103	96	96	96	97	96	89
	2.	50	64	53	54	66	68	49
	3.	78.9	81.8	77.4	76.4	82.1	81.3	69.1
8-31-78	1.	99	94	92	92	93	93	84
	2.	52	57	47	51	54	58	42
	3.	75.9	76.5	70.0	72.5	75.9	76.8	64.4

Table 2.1.1-5

Monthly Temperature Normals and Extremes, ^{o}F,
China Lake, California (1946-1976)

Month	Record High	Maximum	Normal Average	Minimum	Record Low
January	77	57.8	43.1	28.7	0
February	83	63.8	49.0	34.2	14
March	92	69.0	54.4	39.7	17
April	98	76.8	61.9	46.6	28
May	107	86.2	70.7	55.2	34
June	114	95.5	79.4	63.1	42
July	116	102.3	86.2	70.0	52
August	112	100.5	84.1	67.7	50
September	110	94.0	77.2	60.3	39
October	102	81.9	65.4	48.8	21
November	88	68.0	52.4	37.0	18
December	86	58.6	43.7	29.1	2
Annual	116	79.5	64.0	48.4	0

Table 2.1.1-6 Monthly Temperature Extremes, °F
High Desert Stations (including Las Vegas
August 1977 through September 1978

Month	2162 ft Las Vegas NV	2283 ft China Lake	2300 ft Airport Lake	3180 ft Little Lake	3435 ft Rose Valley Ranch	3560 ft Coso Basin	3600 ft Red Hill	3825 ft Haiwee	4150 ft Bishop	5000 ft Cactus Flats
	Maximum and Minimum Monthly Temperatures									
8-77	115 68	113 59	107* 55	N/A N/A	97 * 53	95 * 48	N/A N/A	97* 59	107 51	93 * 48
9-77	109 57	105 49	110* 47	N/A N/A	98 * 37	99 * 37	88 * 46	102* 54	98 36	96 * 41
10-77	96 48	93 36	98* 33	N/A N/A	88 29	65 * 23	94 * 37	91 40	97 29	86 * 38
11-77	84 31	83 23	86* 29	74* 23	74 15	72 11	73 * 39	76 24	78 17	74 * 49
12-77	75 31	77 24	73* 50	71* 27	68 * 16	65 * 16	72 * 27	74* 28	73 20	70 * 59
1-78	66 31	66 26	65* 34	62* 22	58 * 16	58 * 16	62 23	59* 28	61 19	44 * 33
2-78	74 33	74 30	N/A N/A	69 22	64 15	61 * 16	69 20	64* 24	67 20	60 * 20
3-78	85 41	88 37	N/A N/A	66* 33	75 22	81 20	**103 30	80* 30	77 25	67 * 22
4-78	88 40	89 35	N/A N/A	80* 34	76 19	78 25	**104 * 50	81 31	82 25	73 20
5-78	102 46	100 40	N/A N/A	92* 38	94 25	92 * 25	**107 33	97 36	92 28	86 22
6-78	110 62	N/A N/A	N/A N/A	100* 48	100 40	103 * 37	108 * 51	105 53	99 44	95 * 35
7-78	115 66	N/A N/A	111* 54	100* 52	105 40	106 35	108 * 50	106* 51	104 44	99 * 34
8-78	114 61	N/A N/A	117 41	101* 47	109 38	112* 40	109 * 52	109 53	106 41	104 * 32
9-78	106 49	N/A N/A	101* 45	97* 54	N/A N/A	N/A N/A	96 * 52	N/A N/A	94 32	** 8 42

*Only partial data available for the month.

**Maximum temperature questionable

N/A No monthly data available

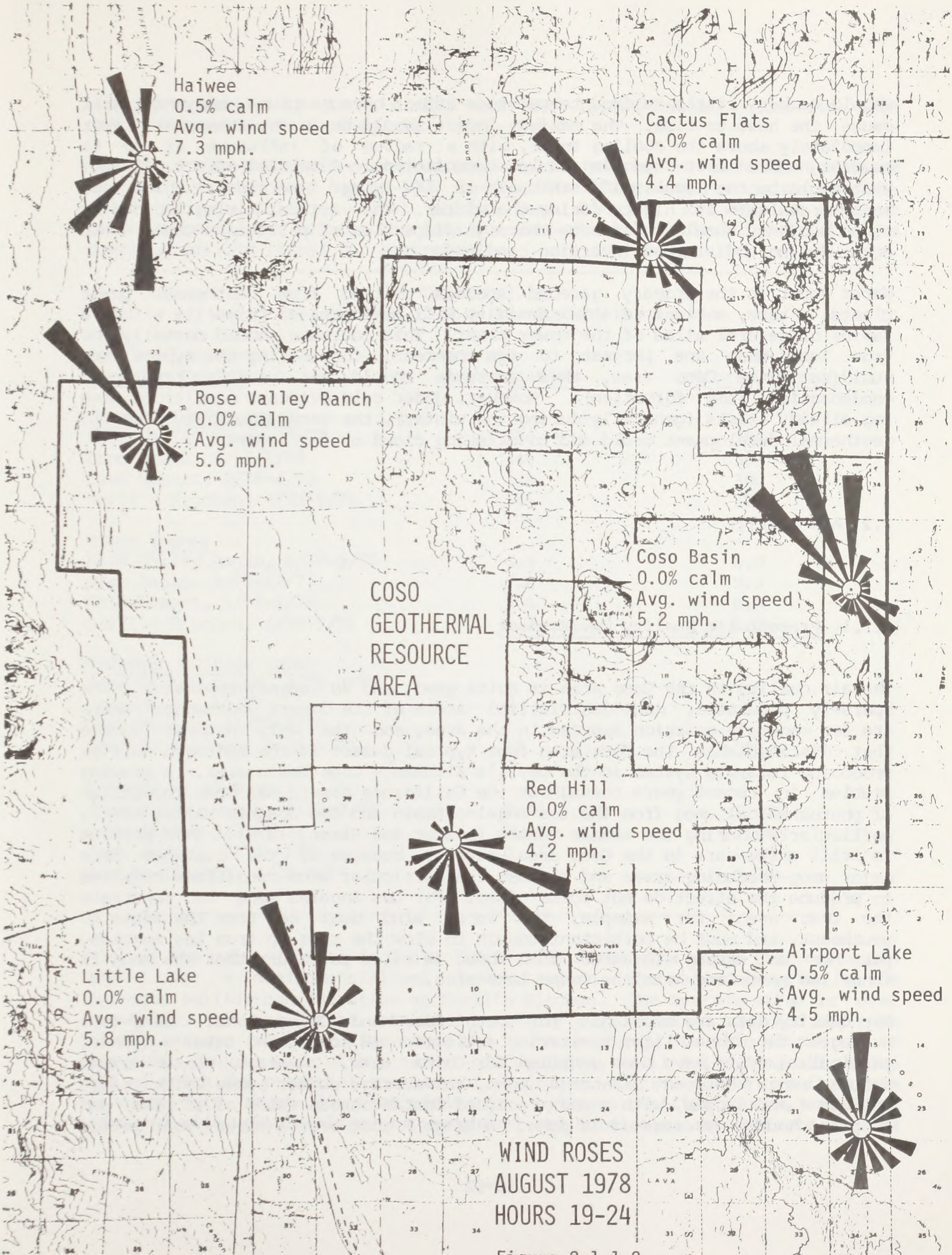
Haiwee
0.5% calm
Avg. wind speed
7.3 mph.
Cactus Flats
0.0% calm
Avg. wind speed
4.4 mph.
Rose Valley Ranch
0.0% calm
Avg. wind speed
5.6 mph.
Coso Basin
0.0% calm
Avg. wind speed
5.2 mph.
COSO
GEOTHERMAL
RESOURCE
AREA
Red Hill
0.0% calm
Avg. wind speed
4.2 mph.
Airport Lake
0.5% calm
Avg. wind speed
4.5 mph.
Little Lake
0.0% calm
Avg. wind speed
5.8 mph.
WIND ROSES
AUGUST 1978
HOURS 19-24

Figure 2.1.1-2

should be very little surface temperature effect because plume buoyancy will cause the heat to rise. The maximum impact should be in the atmosphere layer immediately above the cooling tower, with a radius of influence of up to several hundred feet depending on local conditions. A related effect of waste heat could be the localized disturbance of low-lying inversions, which are most prevalent at night during the winter. The vertical mixing induced by plume buoyancy should cause more thorough dispersion of pollutants than would occur during undisturbed inversion conditions.

Water vapor is the primary gaseous species emitted from geothermal power plants; thus, ambient relative humidity will be increased primarily within a radius of several miles of the power plant. This increase should normally be from less than one percent to ten percent. Considering the typical low humidity in the Coso area, this increase should not usually result in condensation (fog formation). However, under cold overcast conditions when fog already exists (generally during the winter), the excess humidity due to geothermal development could add to existing cloud or fog layers.

2.2 AIR QUALITY

2.2.1 Present Air Quality Environment

The air quality in the Coso area is quite good, and is largely typical of the sparsely populated, nonindustrialized areas of the desert southwest. There are few man-made emission sources in the area, and the only natural source that distinguishes the Coso area from typical desert is the hydrogen sulfide producing fumarole system in the Devil's Kitchen - Coso Basin area. A growing problem in recent years throughout the California desert has been the influx of photochemical smog from the Los Angeles Basin and San Joaquin Valley areas, particularly during the summer months (Lester and Simon, 1978). This problem is still quite rare in the Coso area, however, because of the distance from major smog-producing areas and because the particular wind conditions required to produce the effect do not occur often. For Los Angeles smog to penetrate the Coso area, for example, the local wind must be from the south to southeast, and must be persistent enough to blow the smog up from Los Angeles, yet not so strong (greater than about 12 miles per hour) that the smog is funnelled past Coso into the Owens Lake area.

Air quality data are available for both Coso and China Lake. Long-term averages for ozone, light scattering extinction (B scat), and total suspended particulate (TSP) have been compiled for China Lake. Average winter ozone values range between 2 and 4 pphm, and average summer ozone values range between 4 and 6 pphm, with a peak recorded instantaneous value of 15 pphm and a peak hourly average of 13 pphm. Average B scat over a three- year period was approximately 0.4 (10^{-4} m^{-1}), and the latest annual geometric mean (1977) TSP value was 51.3 ug/m3.

The China Lake NWC staff conducted a monitoring program at several locations in the Coso area from August 1977 to May 1978. They measured carbon dioxide, ozone, hydrogen sulfide, total sulfur, and B scat, as well as ambient temperature and dew point. The data are summarized in Table 2.2.1-1, with the sampling periods listed for each site.

Table 2.2.1-1
Summary of Coso Air Quality Data

Species/Location Sampling Period	Average Concentration	Peak Hourly Average
Carbon Dioxide (ppm)		
Rose Valley Ranch, 9/77	354	380
Coso Basin, 9/77-1/78	346	390
Coso Resort, 2/78-4/78	335	360
Devil's Kitchen, 4/78-5/78	345	370
Ozone (pphm)		
Rose Valley Ranch, 8/77-9/77	4.0	8.0
Coso Basin, 9/77-12/77	3.6	9.0
Coso Resort, 1/78-4/78	3.0	8.0
Devil's Kitchen, 4/78-5/78	4.3	8.0
Hydrogen Sulfide (ppb)		
Rose Valley Ranch, 8/77-9/77	0	-
Coso Basin, 10/77	0	-
Coso Resort, 11/77-4/78	0	-
Devil's Kitchen, 4/78-5/78	22	140
B(scat) (x 10^{-4} m^{-1})		
Rose Valley Ranch, 8/77-9/77	0.46	1.40
Coso Basin, 9/77-1/78	0.38	2.65
Coso Resort, 3/78-4/78	0.27	1.40
Devils Kitchen, 4/78-5/78	0.35	0.80

Most of the values listed in Table 2.2.1-1 lie within the range that one would expect for a nonindustrialized desert region. The major exception is the hydrogen sulfide concentration at Devil's Kitchen. The average value is over two-thirds of the state standard one-hour average of 30 ppb, and the peak hourly average is almost five times the state standard. Devil's Kitchen is a man-made canyon area with a number of fumaroles, drill holes, and old wells, all of which are potential sources of hydrogen sulfide. The monitor was located only about 50 feet from the hydrogen sulfide source, and this, combined with very localized topographical and meteorological effects, would account for the high readings at Devil's Kitchen. Excessive ambient hydrogen sulfide is limited to a small area immediately surrounding Devil's Kitchen. The only other station to record even a trace of H_2S was Coso Resort, which also experiences intermittent fumarole activity within a quarter mile of the monitor.

It is instructive to consider B scat in terms of actual visual range. The Koschmieder formulation (Middleton, 1952) expresses visibility in terms of B scat:

$$V = 24/(3 \times B\ scat),$$

where V is the visual range in miles and B scat is in units (10^{-4} m^{-1}). Referring to Table 2.2.1-1, this yields a maximum long-term average visibility of 90 miles (Coso Resort, 3/78 - 4/78), and a minimum hourly average visibility of 9 miles (Coso Basin). These results indicate generally excellent visibility, with even the lowest long-term average visibility being over 50 miles (Rose Valley Ranch, 8/77-9/77). The 3-year average visibility at China Lake was approximately 60 miles.

Although a full range of pollutants such as CO, NOx, and hydrocarbons was not measured during the Navy study in the Coso area, ozone is generally considered to be a reasonable indicator of the presence of photochemmical smog. The average ozone concentrations were all quite low, falling well below the Federal one-hour average standard of 12 pphm. Thus, photochemical smog appears to be at worst a minor problem in the Coso area, even adjacent to U.S. 395 at Rose Valley Ranch.

In attempting to understand the present air quality at Coso, it is useful to consider the major emission sources in the region. There are major stationary sources (greater than 25 tons per year emissions) at China Lake, Inyokern, Olancha, Ridgecrest, and Trona. None of these lie within the boundaries of the CGSA. Mobile sources include traffic on U.S. 395, the Southern Pacific Railroad through Rose Valley, and aircraft overflights. Table 2.2.1-2 lists the total yearly emissions within the CGSA (EPA, 1977). Aircraft emissions have been estimated by assuming that 10 percent of all flights originating at Armitage Field (China Lake NWC) will fly over the study area (Ouimette, 1974).

Table 2.2.1-2
Emission Rates Within the CGSA
(Tons per Year)

Pollutant	U.S. 395	Railroad	Aircraft	Total
CO	403	1	76	480
Hydrocarbons	63.5	0.5	28	92
Oxides of Nitrogen	108	2	38	148
Particulate	9	--	90	99
Sulfur Oxides	3	--	15	18

Fugitive dust can affect both visibility and public health. Lack of abundant rainfall means that the soil will be dry a great portion of the time, so dust can be re-suspended either by wind erosion or by mechanical turbulence such as automobile traffic. The wind speed threshold for wind erosion of exposed areas is 12 miles/hour (Bohn, Cuscino, and Cowherd, 1978), which is higher than the average wind speed for both Coso and China Lake. Thus, automobile traffic and other mechanical processes such as road grading and mining are the major fugitive dust contributors much of the time. The most recent (1977) annual geometric mean TSP value of 51.3 ug/m^3 for China Lake does not exceed either the state standard (60 ug/m^3) or the Federal primary standard (75 ug/m^3).

A drastic divergence from the normally occurring fugitive dust levels at China Lake is the case of the Owens Lake dust storm, which might occur up to a dozen times a year. Strong winds of 50 miles per hour or more flow in from the north, carrying with them tremendous quantities of dust from the dry bed of Owens Lake. During such episodes, TSP concentrations have been estimated to be well over 1000 ug/m^3 (Reinking, Mathews, and St. Amand, 1975), and visibility can decrease to less than one mile. The dust can extend over an area as large as 3500 square miles (NWC, 1978), encompassing both the Coso and Indian Wells Valley areas.

The 1977 Clean Air Act amendments specify prevention of significant deterioration (PSD) regulations to insure preservation of current air quality in sensitive areas. According to the regulations, all areas are placed in one of three classes. In Class I areas, only very limited air quality degradation is permitted. In Class II areas, moderate deterioration is allowed in line with somewhat limited growth. Class III regulations specify very liberal allowed increments. The Coso study area currently has a Class II designation, although it is possible that it may be reclassified Class I at some future date. Of The nearby National Park Service lands, Death Valley National Monument carries a Class II designation; both Sequoia and Kings Canyon National Parks are Class I. The closest Class I area to the CGSA is Domeland Wilderness Area in Sequoia National Forest, approximately 25 miles west-southwest of Coso Basin.

2.2.2 Impacts of the Proposed Action on Air Quality

This section addresses the air quality impacts of geothermal development considering ambient pollutant levels in terms of state and Federal standards as well as in terms of potential visibility degradation. Further details may be found in the Air Quality Technical Report.

2.2.2.1 Emission Rates

The principal gaseous emissions associated with geothermal development are the noncondensible gases hydrogen sulfide (H_2S) and carbon dioxide (CO_2), water vapor from flow testing and from the cooling tower, and exhaust from cars, trucks, and construction equipment. Trace amounts of mercury (Hg) have also been detected in the cooling tower air in a number of geothermal areas, (Robertson, et al., 1978); boron and arsenic are additional possible trace elements. In addition, fugitive dust will be emitted into the atmosphere as a result of vehicle and construction activity, as well as by wind erosion of exposed areas.

Predicted emission rates for an undeveloped geothermal area such as Coso, are at best rough estimates. The chemical composition of the effluent varies from one geothermal field to the next, and may even vary significantly from point to point within a single field. Thus, most probable emission rates can be predicted, but may have to be updated as the geothermal field is further explored and developed.

Noncondensible gases will be emitted during well flow testing and also from the off-gas ejector during power production. The emission rates of hydrogen sulfide and carbon dioxide for flow testing of one well are estimated to be 3.2 g/sec and 320 g/sec, respectively. For each 50 MW power plant, the carbon dioxide emission rate from the off-gas ejector should be approximately 1000 g/sec. Total H_2S production per plant is projected to be 10 g/sec but it will be scrubbed with 95 percent efficiency giving an actual emission rate of 0.5 g/sec.

The water vapor emission rate per well during flow testing should be approximately 3.2×10^4 g/sec. During power production, water vapor should be emitted from the cooling tower at a rate of 1.1×10^5 g/sec per 50 MW of power production. Cooling tower water is scrubbed of particulate matter before entering the plant cycle, so the cooling tower emissions can be assumed to be essentially pure water vapor, with the exception of trace amounts of mercury and other inorganic impurities (Crecelius, et al., 1976). Mercury emission rates are typically about 1.0×10^{-8} by weight of water vapor emission rates.

Exhaust emissions from automobiles, trucks, and drilling and construction equipment will vary as the level of field development changes, but should reach a maximum during the power plant construction stage. The total yearly average emissions predicted from the exhaust sources during this stage are listed in Table 2.2.2-1 (EPA, 1977). For comparison, the current CGSA emission rates (primarily due to U.S. 395 traffic) are also shown in Table 2.2.2-1.

As with exhaust emissions, fugitive dust emissions due to vehicle traffic and construction will vary with development. The maximum should occur during the high traffic volume periods of power plant construction when the dust suspension rate due to vehicles should reach approximately 200 g/sec per mile of access road during peak traffic periods. The maximum dust emission rates due to wind erosion of exposed areas should also occur during the plant construction and resource utilization periods, when exposed area is at at a maximum. Twelve miles/hour is the threshold wind velocity for dust production; below this value no wind erosion can be expected. The emission rate is a function of meteorological conditions, being proportional to the cube of the wind speed.

TABLE 2.2.2-1
Vehicle and Equipment Exhaust Emissions

Species	Yearly Average Emission Rate (Tons per Year) Existing in CGSA	Predicted During Development
CO	480	300
Hydrocarbons	92	33.5
Oxides of Nitrogen	148	43
Particulate	99	3.6
Oxides of Sulfur	18	3.8

2.2.2.2 Air Quality Impacts

Ambient pollutant levels have been calculated using an EPA approved Gaussian atmospheric dispersion model known as RAMR (*). Input information supplied to

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* A "model" is a mathematical description of the dispersion of a pollutant taking into account the effect of wind speed, wind direction, and atmospheric stability.

the model includes emission rates and other source physical parameters such as stack height and stack gas exit velocity, as well as meteorological information including wind speed, wind direction, mixing height, and atmospheric stability class. The model computer calculations estimate ground level concentrations within approximately a 20 km radius of the source. Models do not provide exact results, but rather give rough estimates. Uncertainties of at least ±50 percent should be attached to any model estimates. A short term model was used in the present calculations making it possible to directly address the one hour average state standard for hydrogen sulfide which is of major interest in geothermal development.

Model calculations were performed under a number of different meteorological conditions which could be expected to occur in the Coso area. In most cases, the maximum ground level ambient concentration was estimated to occur within about a kilometer of the source. In order to understand the air quality impacts of geothermal development, it is useful to point out the maximum calculated concentration of each pollutant and to relate these concentrations to Federal and state air quality standards. The maximum concentrations of gaseous pollutants will be due to vehicular traffic and are shown in Table 2.2.2-2, along with Federal and state one hour average standards. The maxima are predicted to occur under stable meteorological conditions with winds of four miles per hour or less. As is obvious from Table 2.2.2-2, no exceedance of either Federal or state standards is predicted.

TABLE 2.2.2-2
MAXIMUM GASEOUS POLLUTANT CONCENTRATIONS
(Micrograms per Cubic Meter)

Pollutant	Maximum	Federal Standard	State Standard
CO	760	40,000	46,000
Hydrocarbons	70	160(6 a.m.- 9 a.m.)	-------
Oxides of Nitrogen		12	100(annual) 470
Particulate	1.8	260(24hour)	100(24hour)
Oxides of Sulfur	0.4	----	1310

The maximum ambient hydrogen sulfide concentration to be expected from full power plant operation is 21 ug/m^3, exactly one half of the state one hour standard of 42 ug/m^3. The hydrogen sulfide maximum from well flow testing is 33 ug/m^3. Although this is, by itself, well below the state standard, it is possible that power plant operation and flow testing could combine to cause an exceedance of the standard in a localized area. The model reveals that such an exceedance is most likely to occur during periods of wind speed greater than five miles per hour. Field sampling by NWC personnel has shown ambient atmospheric hydrogen sulfide to exist only in trace amounts in most parts of the CGSA, the exception being Devil's Kitchen where the state standard is currently violated due to natural sources.

Maximum concentrations of carbon dioxide and water vapor during full power plant operation are calculated to be 4.2 x 10^4 ug/m^3 and 6.5 x 10^6 ug/m^3, respectively. There are, of course, no government standards for these compounds. Based on the water maximum, the maximum expected mercury concentration is 65 nanograms per cubic meter (ng/m^3), although under most meteorological conditions this number will be about a factor of 10 lower. For comparison, ambient background mercury concentrations tend to be on the order of 1 ng/m^3. The ambient level at which long-term exposure is believed to cause damage to plants and animals (including humans) is approximately 100 nanograms per cubic meter. See the Flora and Wildlife Sections of this ES for more details.

Fugitive dust is typically addressed in terms of 24 hour standards. The state standard is 100 ug/m^3; the Federal primary standard is 260 ug/m^3 and the secondary is 150 ug/m^3. The predicted 24 hour fugitive dust average due to vehicle traffic under stable (worst-case) meteorological conditions is about 1000 micrograms per cubic meter. This exceeds all state and Federal standards for suspended particulate matter. The 24 hour average for around-the-clock power plant grading and construction is 2300 ug/m^3, again exceeding all standards. For comparison, the current annual geometric mean total suspended particulate value is approximately 50 ug/m^3 at China Lake.

The maximum predicted fugitive dust concentration due to wind erosion of exposed areas is 2600 ug/m^3. It should be pointed out, however, that this should occur during periods of extremely high winds (greater than 50 mph), during which natural dust sources commonly cause exceedance of suspended particulate matter standards. The maximum under less extreme conditions (less than 18 mph) is 300 ug/m^3. If the wind remained at threshold (12 mph) for at least eight hours out of twenty-four, then the state standard would be violated; at least twelve hours would violate the Federal secondary standard, and twenty hours would violate the Federal primary standard.

A secondary effect of these fugitive dust emissions will be the endangerment of the health of people in the dust-laden sections of the CGSA. The Federal primary standards were written to protect the public health with an adequate margin of safety, so any exceedance can be viewed as a health hazard.

The model results show that maximum pollutant concentrations should usually occur within about a kilometer of the source, and that levels decrease consistently and rather quickly with increasing downwind distance. Therefore, it can be concluded that any primary pollutant impacts that may arise due to geothermal development will most likely occur within the Coso Range. The probability that government standards will be exceeded in Indian Wells Valley due to Coso development seems to be quite small.

2.2.2.3 Visibility Impact

One of the major air quality concerns is the impact of geothermal development upon visibility. The California desert has traditionally enjoyed very good visibility, and preservation of this visibility is considered to be important both to the public for its aesthetic value, and to the NWC for its value in allowing weapons to be observed from long range during tests. The Navy is concerned with visibility not only in the "visible" range (i.e., as perceived by the human eye), but also in the infrared due to their weapons system requirements. Both spectral regions are addressed in this section.

Considering the emission levels projected for geothermal development at Coso, the gaseous pollutant most likely to lead to visibility degradation is hydrogen sulfide. Hydrogen sulfide in itself, however, should not cause an impact. Rather, hydrogen sulfide can react to form sulfur dioxide, which can then undergo further chemical conversion to sulfate aerosol which, along with nitrate aerosol, is one of the most common visibility reducing species (see, for example, Cass, 1976). The hydrogen sulfide to sulfate conversion process is rather slow, so hydrogen sulfide emitted at Coso on a given day will not have formed appreciable quantities of sulfate aerosol until the next day.

Due to the time scale involved, the dispersion of sulfate aerosol should have a regional impact, not confined to the Coso study area. Considering the prevailing wind direction at Coso, the adjacent area of most interest would be Owens Valley and Indian Wells Valley. Since the dispersion models used in this analysis are not regional models, the sulfate concentrations in these areas cannot be calculated explicitly. As a conservative estimate, however, an upper limit to regional visibility impairment can be calculated using the dispersion model results for the outskirts of the CGSA. Doing so, full power plant development can be estimated to decrease visibility from about 61 miles to about 55 miles. This represents approximately 10 percent decrease in visibility. Although this is an upper limit and dispersion should decrease the visibility impacts dwonwind of the CGSA, it can nevertheless be expected that some degree of visibility degradation will occur throughout the extent of Owens Valley and Indian Wells Valley, depending upon wind direction. The NWC has indicated that this amount is not likely to adversely affect their mission. (See the Air Quality Technical Report.)

Fugitive dust from wind erosion has a potential impact on visibility only when the wind velocity is above the 12 mph wind erosion threshold (approximately 10 percent of the time). Normally under these circumstances, however, natural dust sources have already markedly decreased the visual range. During an Owens Lake dust storm, for example, which might occur up to a dozen times a year, strong winds of 50 mph or more flow in from the north, carrying with them tremendous quantities of dust from the dry bed of Owens Lake and decreasing visibility to less than one mile. Project-related disturbed area erosion should have little further effect. A more important impact ascribable to geothermal development is that of dust from vehicle traffic and construction activities during sub-threshold winds, when wind erosion will not be a factor. This is likely to have a local rather than a regional impact, since the heavier dust particles commonly settle out within a few kilometers of their source. Again using a conservative model to calculate the upper limit to the visibility impact, one can predict a visual range of 51 miles, compared to the annual mean of 61 miles, a decrease of 16 percent. However, this assumes the dust cloud to extend over the entire visual range (which is usually not the case), so the actual dust visibility impact will probably not be as severe as indicated here.

The areas of visibility impact due to fugitive dust and sulfate aerosol should not overlap. Dust impact is a localized effect because heavier particles settle out as dispersion progresses. Conversely, suflate aerosol will not normally affect the area adjacent to the source because of the 24 hour hydrogen sulfide to sulfate conversion time. The two effects should cause a cumulative reduction of visibility only when both dust and sulfate concentrations are high and the field of view crosses through both the local source area and the sulfate-laden extended region. The cumulative effect should never be any greater than the previously mentioned worst case decrease of 16 percent.

A specific consideration in terms of air quality, and visibility in particular, is that of Class I areas. Class I areas in the Coso region are Sequoia and Kings Canyon National Parks, and Domeland Wilderness area in Sequoia National Forest (approximately 25 miles from the CGSA). Due to the meteorology and topography of the area, it is unlikely that more than trace amounts of pollutants from the Coso geothermal development would find their way to these areas. Easterly, up-slope winds extending to the Sierra Nevada crest are extremely rare. Thus, it can be estimated that there will be no impact upon the Prevention of Significant Deterioration (PSD) increments allowed for Class I areas. Nevertheless, there could be visibility impacts in terms of vistas from mountain peaks in the Class I areas, looking across Owens Valley or Indian Wells Valley. The impact would most likely manifest itself as a uniform haze in the valley areas. The upper limit to visibility degradation discussed in this section would apply here. Domeland is the closest Class I area to Coso; however, it has few areas over 8000 feet in elevation, and thus offers few sweeping views to the east because of the intervening Sierra Nevada ridge. Sequoia and Kings Canyon, on the other hand, have a number of peaks at over 12,000 feet along their eastern boundaries, including Mt. Whitney at 14,494 feet, so visibility may be of more interest in these parks.

The main infrared absorbing species which can be expected from geothermal development are carbon dioxide and water vapor. Conservative regional estmates assuming full power plant development predict upper limit ambient level increases of 0.2 percent and 2.0 percent for carbon doixide and water, respectively. These increases should be insignificant in terms of infrared attenuation since natural levels of carbon dioxide and water can fluctuate more than this quite readily and quite often.

2.3 NOISE

2.3.1 Existing Noise Setting

Although the Coso study area is largely a very quiet, undeveloped region, there are a number of noise sources which can be considered significant. The greatest constant noise source in the area is U.S. 395, which runs approximately north-south through the western section of the CGSA. Computer modeling by Caltrans using traffic volume data has produced a noise contour map for U.S. 395 at Dunmovin, near the northwest boundary of the Coso study area (Caltrans, 1978). This map is shown as Figure 2.3.1-1, with all sound contours reported as L_{10} values, using the A-weighted decibel scale. As a general rule, it can be approximated that the ambient noise level decreases by 6 dBA with each doubling of distance from the source, so the highway noise contribution will be reduced to the typical desert background level of approximately 40 dBA (L_{10}) within about a mile of the highway.

There are several other man-made noise sources within or adjacent to the CGSA. There are mines near Cactus Peak, Haiwee Dam, and Red Hill, and an alfalfa ranch is located inside the study area just to the southeast of the abandoned community of Dunmovin. China Lake NWC contributes both ground-based and airborne noise sources. Navy vehicles use U.S. 395 and the Coso access road, and military aircraft can cause elevated noise levels for brief periods throughout the study area due to noise from the aircraft engines as well as from sonic booms. Military aircraft and small private planes and helicopters occasionally use the Rose Valley airspace as a north-south flyway. Rose Valley is also a low-level corridor frequently used by the Navy and Air Force during air combat manuevers.

Natural sources can make major contributions to ambient noise levels in the CGSA. In many sections, wind noise is probably the greatest of all noise sources, especially during the spring when windspeeds tend to reach a maximum. Rainstorms also provide limited periods of elevated natural noise, and large animals can make small contributions to natural ambient levels.

There are few existing human noise receptors outside of the western section of the CGSA. A few ranchers live along U.S. 395 in Rose Valley, and there is a small settlement at Little Lake, which includes a hotel and a gasoline station. There are workers at the mines and ranches in the area, and NWC personnel periodically visit most sections of the CGSA. However, none are stationed there, and seldom does anyone stay overnight. Two highly sensitive intermittent use areas are Coso Hot Springs and the Prayer Site near Devil's Kitchen, both of which are used periodically for Native American religious and medicinal purposes. There are no permanent residents at either of these locations. The largest population of human noise receptors in the CGSA consists of transients along U.S. 395. Most of these people do not stop in

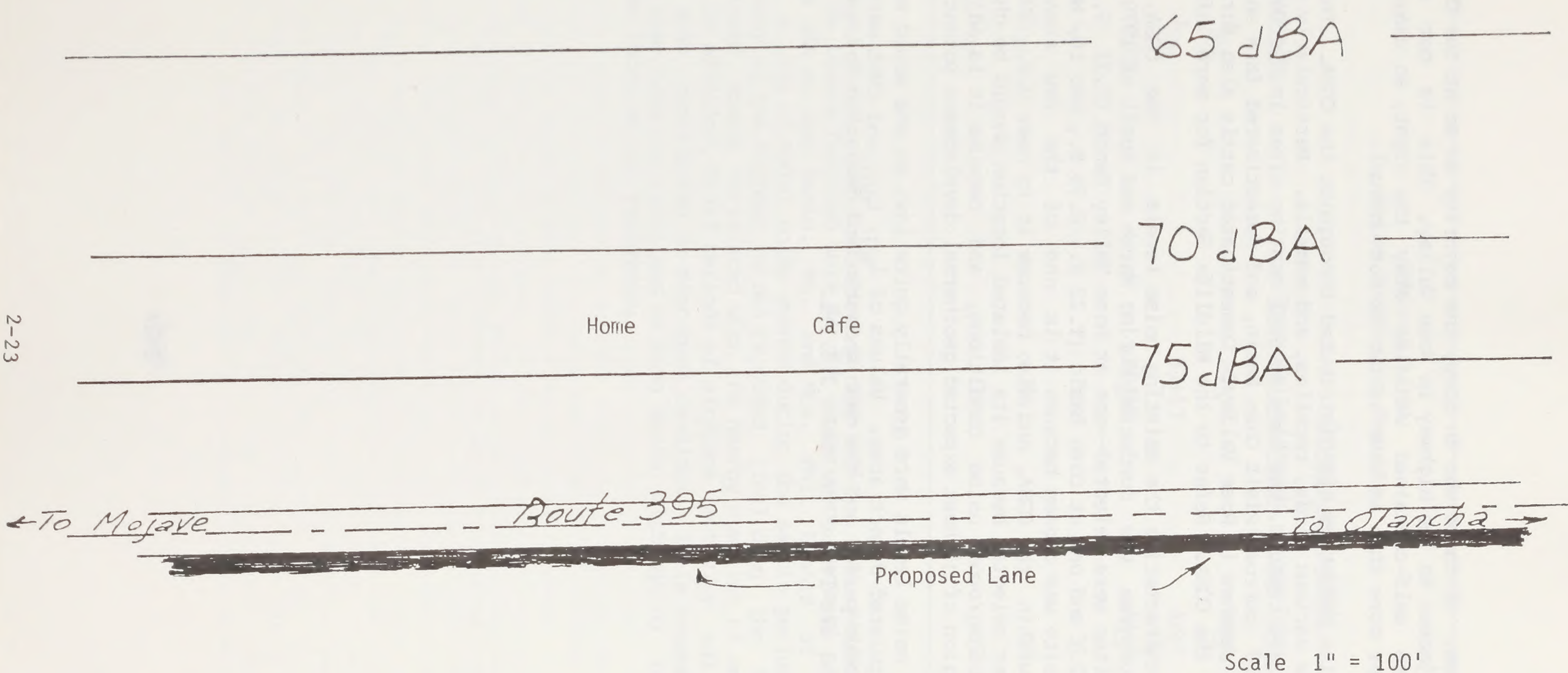


Figure 2.3.1-1 Existing Noise Contours at Dunmovin Resort, 1978

the Coso area. Of those who do stop, the majority do so at the Coso Junction Rest Area adjacent to the highway in Rose Valley. This is not a campsite, although some self-contained vehicles stay the night, so usage by any one individual for more than an hour or two is not unusual.

Non-human noise receptors are distributed throughout the CGSA. Indigenous to the area are various birds, reptiles, and mammals. Particularly sensitive to excess noise are raptors, who have several nesting sites in the Coso Range. A herd of wild burros visit Coso Basin, and domesticated farm animals can be found at the ranches in Rose Valley. Domesticated cattle also forage on the range within the CGSA. Refer to the Wildlife Section for more information.

In order to characterize the existing noise levels in the CGSA, a limited monitoring program was conducted during March and April of 1979. Two field monitoring sites were selected--one at Rose Valley Ranch (T.21 S., R.37 E., sec 26, S 1/2.) and one at Coso Basin (T.22 S., R.39 E., sec 10, NW 1/4). The Rose Valley site was chosen because it is one of the few areas of human habitation within the CGSA, and also because it is near U.S. 395. The Coso Basin site was selected because its isolated location should be characteristic of desert background noise conditions, and because it is adjacent to the localized region of highest expected geothermal development potential.

The observed noise levels were generally quite low, as one would expect for a largely unpopulated desert area. Values of L_{eq}, L_{dn}, and CNEL were calculated for each 24-hour period and the mean and standard deviation for each site were determined and are listed in Table 2.3.1-1.

Table 2.3.1-1
Noise Monitoring Results

Quantity	Sound Level (dBA) Rose Valley Ranch	Coso Basin
L_{eq}	52±18	40±5
L_{dn}	57±17	44±7
CNEL	58±17	44±7
L_5	55	51
L_{10}	46	43
L_{20}	37	33

Values L_5, L_{10}, and L_{20} are also shown in the table. The maximum 10-minute average noise levels recorded were 94 dBA (instrument maximum) at Rose Valley Ranch and 59 dBA at Coso Basin. Mr. and Mrs. Phil Hennis of Rose Valley Ranch kept a log of major noise events during the sample period, and it was found that many of the highest values recorded (including the 94 dBA peak value mentioned above) correlated with the nearby opertion of unmuffled farm equipment. In addition, brief periods of airplane activity and periods of high wind also contributed to near-peak readings. It is assumed that these two sources also made contributions at Coso Basin, although no log was kept there because there are no residents.

2.3.2 Impacts of the Proposed Action on Noise

Noise impacts can result from direct geothermal activities such as well drilling and power plant operation, as well as from related activities such as automobile and truck traffic. Ambient noise levels should increase during the exploratory and early development stages, and should reach a maximum during the intensive field development and power plant construction phases. The noise impacts of geothermal development without mitigation measures are analyzed in this section. (See the Noise Technical Report.)

Noise sources due to direct geothermal activity will be restricted to several clearly defined areas. Vehicle noise sources, however, will exist intermittently along the entire network of roads which will be utilized during geothermal development and power production. U.S. Highway 395, which runs approximately north-south through the western section of the CGSA, is presently a heavily travelled roadway, with an average traffic volume of 4200 vehicles per day and a peak volume of 7600 vehicles per day on summer weekends. The approximately 300 vehicles per day that Coso geothermal development would contribute to this traffic volume should not significantly alter the current noise contours along the highway. Noise impacts should be observed, however, on the secondary access roads within the CGSA. These roads are currently lightly travelled, with an average of 20 or fewer vehicles per day. Single noise events during geothermal operations will range from 90 +dBA at roadside when trucks pass a point to 55 to 60 dBA at the passage of a small vehicle (NWC, 1979).

Noise impacts due to direct geothermal activity can occur at several stages of development. The first major impacts should come during site preparation and construction of well pads and power plants. Grading, in particular, could be a significant noise source since it may require several large pieces of earth-moving equipment to be operating simultaneously. Grading and construction equipment noise can be of two types; continuous noise generated by equipment such as generators or tractors, and sporadic noise from devices such as jack hammers or power saws. Typical noise levels from equipment likely to be used in geothermal construction are listed in Table 1.3.6-1. Table 2.3.2-1 shows typical overall drill site preparation and construction noise as a function of distance from the source. All values in Table 2.3.2-1 are taken from a noise analysis of a fluid-dominated geothermal project in the Imperial Valley (County of Imperial, 1979).

Table 2.3.2-1

NOISE FROM GEOTHERMAL DEVELOPMENT

Activity	Noise Level (dBA) At 100'	200'	500'	1000'	2000'	5000'
Site Preparation And Construction	78	73	66	58	50	38
Well Drilling	75	68	60	53	44	30
Well Cleanout	75	68	58	50	41	25
Flow Testing	78	73	66	59	52	42
Plant Operation	72	67	58	51	43	28

Further noise impact is likely to occur during drilling, cleanout, and flow testing of new wells. These are short-term operations compared to continous processes such as power plant operation. Cleanout, for example, commonly lasts only a few hours; well drilling requires several weeks of activity. Typical noise levels associated with drilling, cleanout, and testing activities are shown in Table 2.3.2-1.

Operation of the power plant represents the major long-term continuous noise source resulting from geothermal development. Major contributors include cooling towers, turbines, and steam jet ejectors. Because the cooling tower is physically large and has a large band frequency spectrum, it becomes the dominant noise source at distances greater than 200 feet from the unit (PG&E, 1979). Table 2.3.2-2 shows the contributions of individual power plant operations at close range (PG&E, 1979).

Changes in L_{eq}, L_{dn}, and CNEL values as a result of geothermal development will be a function of distance from the noise source as well as duration of the noise. The numbers listed in Table 2.3.2-1 are good approximations of L_{eq} values because they are all representative of long-duration continuous processes. L_{eq} values for non-continuous processes are more difficult to predict, but can often be approximated using similar conditions continuous processes. For example, heavy truck traffic on an access road during the construction phase should be similar to site preparation and can thus be estimated from Table 2.3.2-1. L_{dn} and CNEL values should be slightly higher than· the numbers in Table 2.3.2-1 because they are more heavily weighted in the night and evening that is L_{eq}. Due to the logarithmic nature of the decibel scale, the impacts of geothermal development upon existing L_{eq}, L_{dn}, and CNEL values discussed in this chapter are not linearly additive. The logarithmic scale weights large values very heavily, so if the current background is more than about 5 dBA higher than the predicted geothermal contribution to the noise level, it can be approximated that the background will not be changed. Similarly, if the geothermal contribution is greater than five dBA above background, it can be estimated to be the new background.

Table 2.3.2-2
NOISE FROM POWER PLANT OPERATION

Noise Source	Distance (feet)	Noise Level (dBA)
Cooling Tower	10	85
Outside Turbine Building	25	75
Steam Jet Ejector	10	93

The noise levels estimated in this section need to be considered in two ways. First of all, the local effects upon construction and power plant workers should be addressed. These workers will be in close proximity to the noise sources for usually eight hours per day. They will be exposed to both continuous and short-term (intermittent) noise. The state standards for occupational noise exposure are shown in Table 2.3.2-3 (California Administrative Code). Examination of the previous tables in this section reveals that several operations can cause these standards to be violated at close range.

Table 2.3.2-3
STANDARDS FOR OCCUPATIONAL NOISE EXPOSURE

Duration for Day (hours)	Noise Level (dBA)
8	90
6	92
4	95
3	97
2	100
1-1.25	102
1	105
0.5	110
0.25 or less	115

The other major noise consideration concerns people who are in or adjacent to the CGSA, but not in the immediate vicinity of any geothermal development. Most such areas of human noise reception lie adjacent to U.S. Highway 395. There are presently people living in Rose Valley and at Little Lake, and it has been suggested that a village may be constructed near the Coso Junction Rest Area, to house geothermal workers. Transients on U.S. 395 also stop at Coso Junction Rest Area, usually for periods of an hour or less. The data in Table 2.3.2-1 predict that a hypothetical power plant built more than one and a half miles from U.S. 395 should not be audible over the 52 dBA background noise level near the highway. Trucks and cars on the highway and on access roads should cause intermittent noise as they pass by human noise receptors. For reference, a summary of noise levels identified as requisite to protect public health and welfare with an adequate safety margin is presented in Table 2.3.2-4 (EPA, 1974).

Table 2.3.2-4
RECOMMENDED SAFE NOISE LEVELS

Effect	24-hour Average Noise Level (dBA)
Hearing Loss	70
Outdoor Activity Inteference and Annoyance	55
Indoor Activity Interference And Annoyance	45

The area of most probable geothermal development lies six to eight miles to the east of U.S. 395, in the vicinity of Devil's Kitchen. Also in this area is an Indian Prayer Site and Coso Hot Springs, both of which are used intermittently for religious observances. Power production near these two sites could have a significant noise impact, so topographical noise contours were calculated assuming a power plant approximately one mile from each site. The contour lines represent L_{eq} values as a function of distance from the noise source.

The resulting contour maps are shown for the Prayer Site and for Coso Hot Springs in Figures 2.3.2-1 and 2.3.2-2, respectively. In each figure, the power plant source is shown at the center of the polar graph and the receptor is shown as a triangle. The power plant in Figure 2.3.2-1 is at the site of Coso Geothermal Exploratory Hole (CGEH) No. 1; in Figure 2.3.2-2 it is in the Coso Basin area approximately one mile southeast of Coso Hot Springs. Both maps are the same scale. The contours are shown without consideration of ambient background noise levels; any values lower than the L_{eq} value of 40 dBA reported in this chapter will actually be at 40 dBA. Thus, it is seen in both figures that the noise levels at both religious sites will be at background if power plants are located as shown.

The noise impacts upon non-human receptors should also be considered. Many animals will avoid an area when there is excessive noise, resulting in changes in mating, feeding, migratory, or nesting habits. Raptors are particularly sensitive to noise changes, and the Coso area is one of the their nesting sites. Refer to Chapter 2 Wildlife section.

In summary, the construction and operation of a geothermal power plant (including related vehicle traffic) represents a significant noise source to workers in the immediate vicinity of the plant. Geothermal activities should be audible within about a mile and a half of the noise source, but for

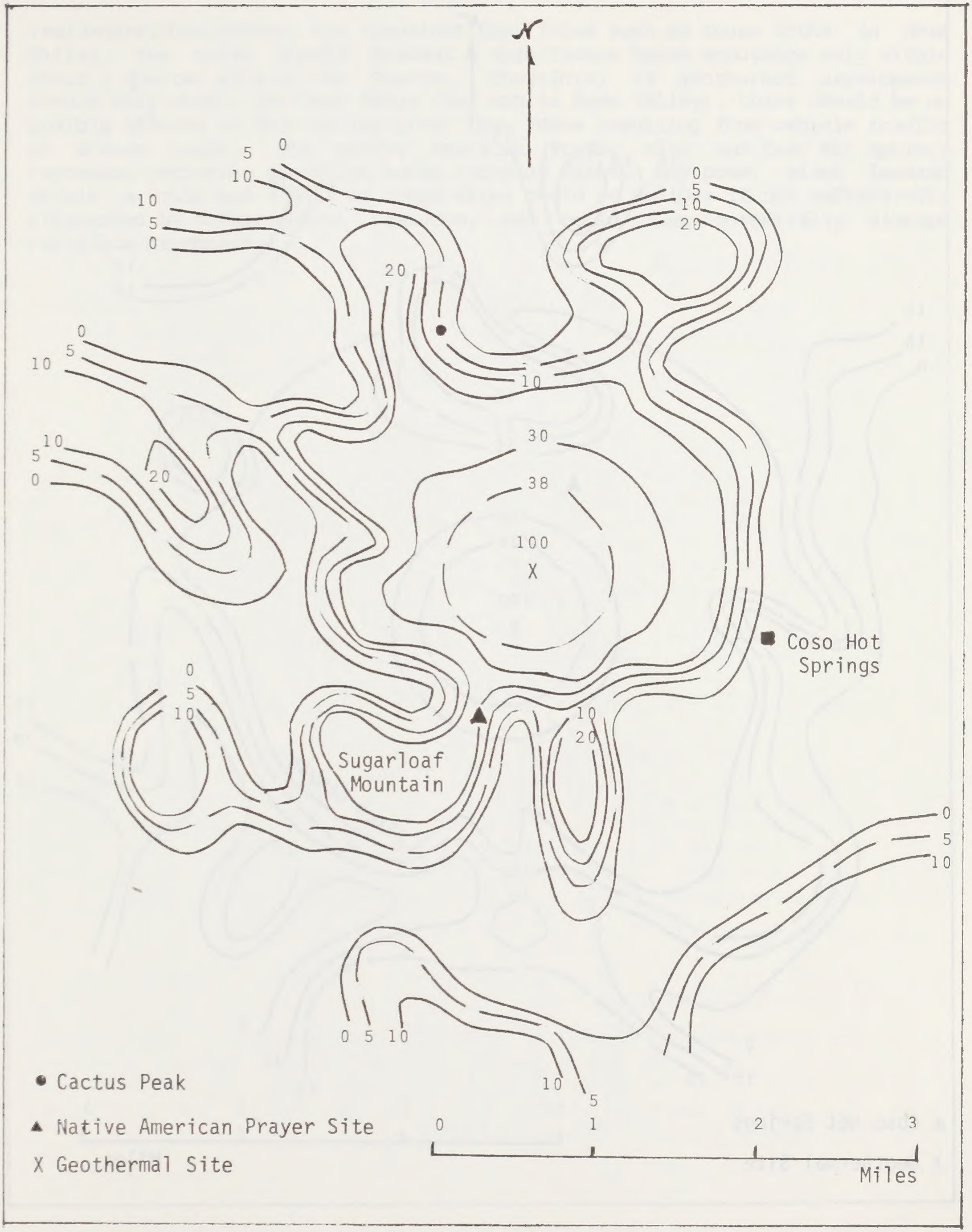


Figure 2.3.2-1 Prayer Site Noise Level Contours (dBA)

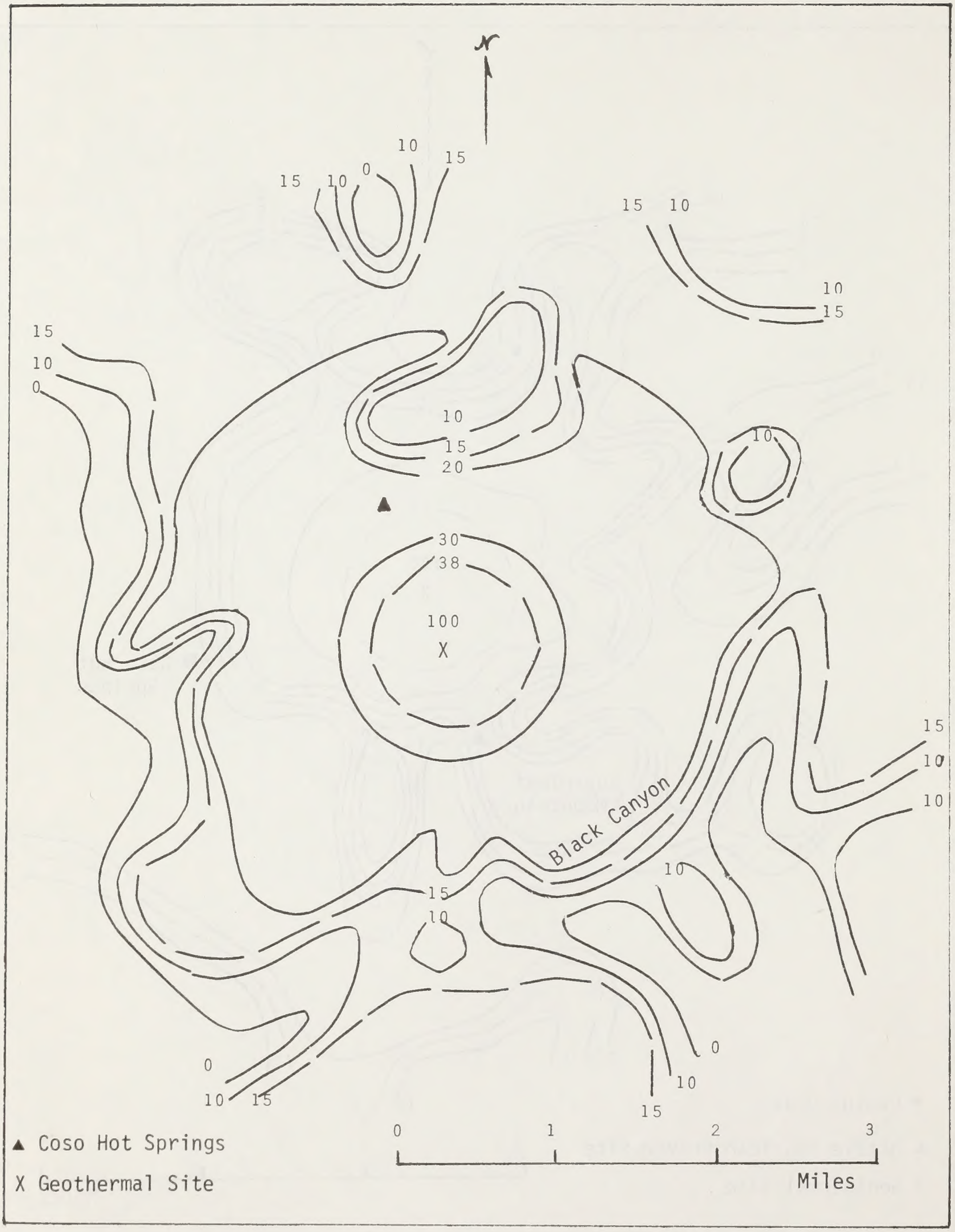


Figure 2.3.2-2 Coso Hot Springs Noise Level Contours (dBA)

residences, businesses, and transient facilities such as those found in Rose Valley, the noise should present a significant human annoyance only within about a quarter mile of the source. Therefore, if geothermal development occurs only within the Coso Range (and not in Rose Valley), there should be no audible effects in Rose Valley other than those resulting from vehicle traffic on access roads. the Native American Prayer site and Coso Hot Springs represent extremely sensitive human receptor sites. Any power plant located within a mile and a half of these sites could be audible if not sufficiently attenuated by topographical features, and could thus potentially disrupt religious ceremonies.

2.4 GEOLOGY

2.4.1 Present Geologic Setting

2.4.1.1 Regional Geology

The CGSA is in the western Basin and Range structural province of southeastern California, separated by Rose Valley from the adjacent Sierra Nevada province (Figure 2.4.1-1). It is about 45 miles north of the east-west trending Garlock fault which forms the boundary between the Mojave Desert and Basin and Range provinces.

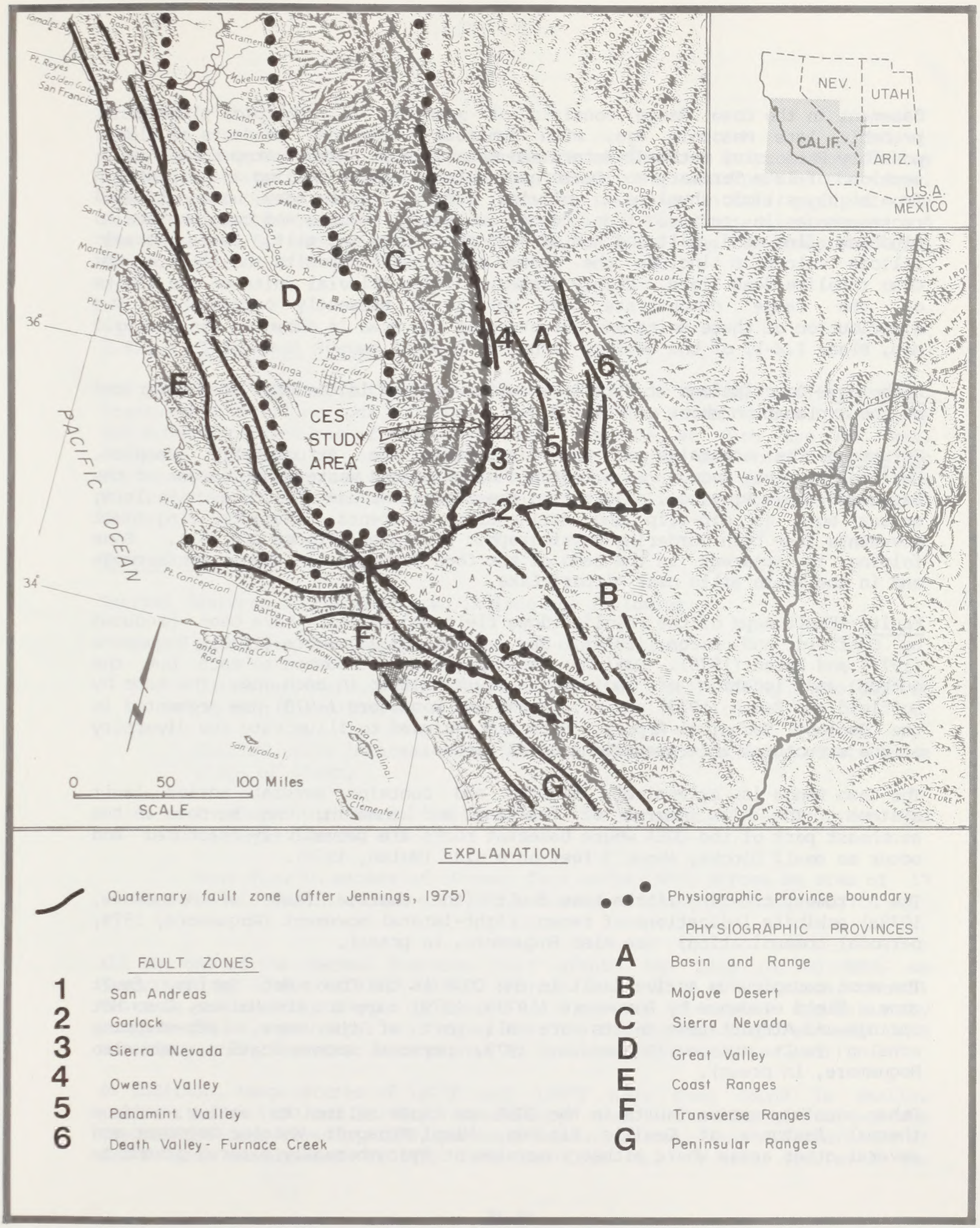
The Basin and Range province is characterized by northerly trending fault block mountains separated by deep alluvial valleys. It is an area of high heat flow and general east-west crustal extension. The oldest rocks exposed in the western Basin and Range province are complexly folded Precambrian metasediments and metavolcanics. These are intruded by Jurassic to late Cretaceous stocks and plugs. The intrusives range in composition from gabbro to granite, with quartz-monzonite and granodiorite predominant.

Late Cenozoic volcanics, ranging from rhyolite to basalt, unconformably overlie the intrusive and older rocks. These include the silicic volcanics of the Coso rhyolite dome field, west of Coso Hot Springs. The volcanic rocks are interbedded with terrestrial clastic and lacustrine sedimentary deposits.

Relief of the western Basin and Range is rugged, due primarily to movement on the northerly trending, high angle normal faults. However, a number of major Basin and Range faults such as the Panamint Valley and Death Valley - Furnace Creek fault zones east of the CGSA and the Owens Valley to the north (Figure 2.4.1-1) have features in common with the San Andreas fault, e.g., great length and consistent right-lateral offset. Several active right-lateral faults also occur within and south of the Coso Range (Roquemore, 1978b).

2.4.1.2 Local Geology

Topography of the CGSA is typical of Basin and Range structure, with highest elevations in the north and a gradual southwest slope. Maximum elevations reach 5947 feet in the northeast corner of the CGSA, along the eastern Coso Range. The minimum elevation of 2800 feet is in Coso Basin. Most of the area is accessible with some portions quite rugged.



Location Map Showing Physiographic Provinces and Major Faults

Figure 2.4.1-1

Basement in the Coso Range consists of granitic to gabbroic plutons of probable late Mesozoic age, with numerous widespread pendants of older, possibly Paleozoic, metasedimentary and metavolcanic rocks. Atop these is a section of late Tertiary and Quaternary volcanic rocks ranging in composition from highly silicic rhyolite to olivine basalt. Quaternary unconsolidated rocks range in texture from coarse volcanic breccia and conglomerate to windblown fine sand, silt and ash, and to playa clay and silt. Late Cenozoic silicic volcanics include the domes, pyroclastic deposits and flows of the Coso rhyolite dome field. Highly dissected older alluvial units on the flanks of the range demonstrate that uplift is presently continuing. The distribution of these units and structure of the area is shown on the Geologic Map, Plate 2.4-1, of the Geology Technical Report.

Lithology--Descriptions of lithologic units exposed in the CGSA are summarized on the explanation sheet of Plate 2.4-1.

Structure--The mountains of the Coso Range are structurally complex. Regionally, they occur as a tectonic block on the westernmost border of the Basin and Range Province, adjacent to the Sierra Nevada Province. Faulting occurs both as dip-slip and strike-slip movements, characterizing fault movements from both bordering physiographic provinces (Figure 2.4.1-1). Some folding is apparent in the beds of the Coso formation in the northern range and in the White Hills near Airport Lake.

Faults--Fault maps of the rhyolite dome field and vicinity have been produced by Duffield and Bacon (1978), St. Amand and Roquemore (1978), Roquemore (1977) and Hulen (1978). Dominant fault patterns are common to each but the number and location of individual faults differ in each one. The maps by Duffield and Bacon (1977) and St. Amand and Roquemore (1978) are presented in the Geology Technical Report. Both are included to illustrate the diversity of the structural interpretations in this area.

The Coso Range is extensively faulted and contains several active fault systems. The high degree of faulting and shearing can be seen in the southeast part of the CGSA where basement rocks are pervasively fractured and occur as small blocks, about 3 feet on a side (Hulen, 1978).

The northwest trending Little Lake fault (the Charlie fault of Roquemore, 1978a) exhibits indications of recent right-lateral movement (Roquemore, 1979, personal communication; see also Roquemore, in press).

The most conspicuous active fault in the CGSA is the Coso Hot Springs fault zone. Field evidence by Roquemore (1978a, 1979) suggests the Haiwee, Coso Hot Springs and Airport Lake faults are all part of the same, left-stepping echelon fault system (Roquemore, 1979, personal communication, see also Roquemore, in press).

Other possibly active faults in the CGSA are those related to active surface thermal features at Devil's Kitchen, Nicol Prospect, Wheeler Prospect and several other areas where either fumaroles or hydrothermally altered ground is present.

A highly dissected older fan on the west side of the Coso Range in Rose Valley is an indicator of uplift continuing along the west part of the range. Gravity data (Healy and Press, 1964) show that alluvium in this part of the valley abruptly deepens several thousand feet. This large displacement and the dissected fan suggest normal frontal faults bound the southwestern Coso Range.

2.4.1.3 Geothermal System

The geothermal system in the CGSA consists of surface thermal manifestations, fractured crystalline rock containing hot fluids and a heat source. Presently the subsurface features of the geothermal resource at Coso are not well defined. Details of any geothermal system can be confirmed only through exploration drilling, well tests and fluid production. The components of the Coso system that are known, and exploratory drilling to date, are discussed below.

Thermal Features

Thermal features of the Coso area include the following:

Fumaroles, mud pots, and steaming warm ground,

Quaternary mercury mineralization, probably still being deposited at certain fumaroles,

Shallow wells in areas of no surface thermal discharge that issue wisps of steam,

Intense hydrothermal alteration of Quaternary sedimentary and volcanic debris, and

Heat flow in excess of 10 heat flow units (HFU) across an area of 17 sq mi, and in excess of 5 HFU across approximately 32 sq mi.

All but one of the thermal features fall within the zone of 10 HFU, as described by Combs (1975, 1976) (Figure 2.4.1-2). At a minimum, thermal features occur within a zone of about 6 or 7 sq mi, elongated approximately north-south on a principal axis along the Coso Hot Springs fault and west on a secondary axis, from Coso Hot Springs to Devil's Kitchen (Plate 2.4-1).

In addition, temperatures of 102°F and 199°F have been found in shallow gradient holes (150 and 312 ft, respectively) over 1 mile distant from surface thermal features (Koenig, 1978, personal communication); and a temperature of 288°F was encountered at 375 feet in Coso No. 1 hole, drilled in the

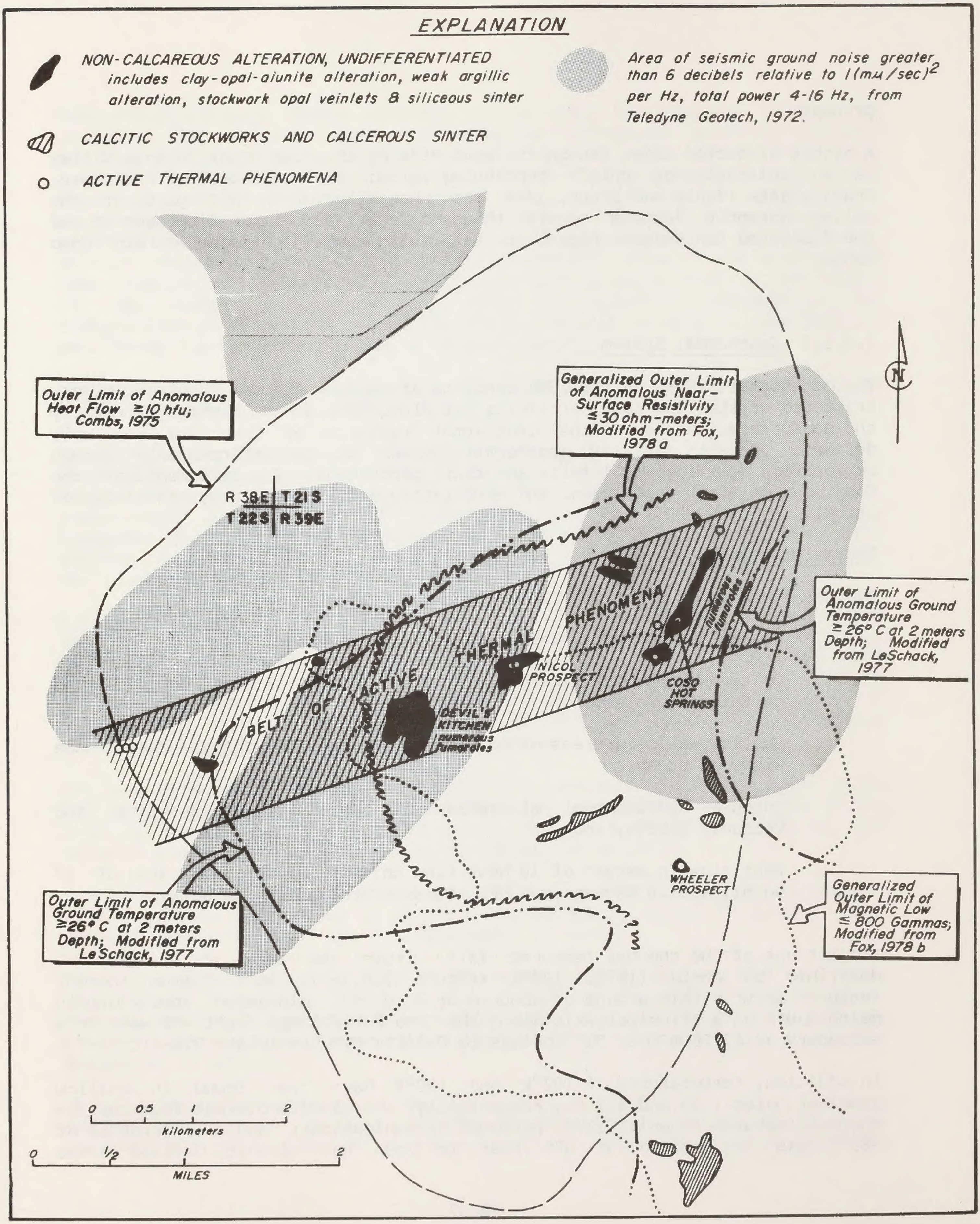


Figure 2.4.1-2 Generalized Alteration and Geophysical Map (modified from Hulen, 1978)

principal fumarole zone at Coso Hot Springs (Austin and Pringle, 1970). On the western flank of Sugarloaf Mountain, a series of shallow drill holes in altered ground produce wisps of low-pressure steam. No surface thermal discharges existed prior to this drilling.

With the exception of Sugarloaf Mountain and two perlitic domes south and northwest of the Devil's Kitchen, no thermal features are known at any other of the 38 volcanic domes. Many of these domes lie outside of the 5 HFU heat flow anomaly as presently defined by drilling (Combs, 1975, 1976).

No thermal features are observed in association with the youngest basaltic cinder cones and flows, despite their equivalence in age to the rhyolite domes. The few heat flow holes drilled near or within the Quaternary basalt field have heat flow values of about 2.5 to 3 HFU.

<u>Geothermal Reservoir and Fluid at Coso</u>

The extent, permeability and exact bounds of the geothermal reservoir have not yet been defined. However, it is known that the geothermal reservoir rocks are fractured Mesozoic granitic basement rocks of the southern Coso Range. It is envisioned as a boiling water table system (Galbraith, 1978, pp. 22-25). Based on currently determined ground and water level elevations the top of the reservoir is at about 3660 feet (see Hydrology Section). The depth of the fluid circulation is not known.

The geothermal system at Coso is structurally controlled. Fluid is "piped" along subsurface faults and other fractures which form secondary permeability in otherwise impermeable basement rocks. The older northwest to west-northwest and east-northeast faults are important in development of permeability. Crushed zones within these are brittle. When these faults are cut by younger faults, permeable zones are produced. The geothermal system is bounded on the east by the Coso Hot Springs fault where high heat flow values abruptly terminate. Boundaries on the north, south and west appear more gradational.

Earlier estimates of the reservoir size were much greater due to previous structural interpretation of the geothermal reservoir area as a "caldera-like feature" (Duffield, 1975). It was envisioned as encompassing a 1500-square-kilometer oval-shaped zone of late Cenozoic ring faulting (Duffield, 1975; Renner, et al., 1975). However, evidence to support this ring fault structure has been lacking and current structural interpretations omit this feature (Duffield and Bacon, 1977).

Primary porosity of reservoir rocks is nil with secondary fracture porosity developed. Fracture porosity will vary widely from place to place, depending on the size and openness of fractures. Based on the known hydraulic properties of similar reservoirs, porosity of the Coso geothermal fluid bearing rocks probably varies from 3 to 5 percent (see Appendix B for discussion). Direction of thermal water flow, storage and the extent of the reservoir are structurally controlled.

Fractures in basement rock occur as joints, cleavage planes, young fault zones and shatter zones at major fault intersections. Dominant fracture trends are north-northeast, east-northeast and west-northwest. Intersections of north-northeast and east-northeast faults appear to control major thermal discharges at Coso Hot Springs, Devil's Kitchen and the Nicol Prospect.

Geothermal fluid is sodium chloride water with total dissolved solids of around 5000 to 6000 mg/l. Localized steam caps above the thermal water table may be present in fumarole areas (Austin and Pringle, 1970). Typical geothermal water analyses from the two exploration wells, Coso No. 1 and CGEH-1 are presented in Table 2.5.1-3. Maximum equilibrium reservoir temperatures estimated by Fournier, et al. (1978) from water chemistry data are 240°C to 275°C. Maximum observed temperature in CGEH-1 was 195°C (382°F) at 1900-foot depth along a fracture zone (Galbraith, 1978).

Geothermal Exploration Drilling

The only deep exploratory hole, CGEH-1, was completed in December 1977 to a depth of 4845 feet. The CGEH-1 drill site is located in a closed valley about 2 miles west of the Coso Hot Springs. The site is bounded by four rhyolite domes to the west and south and high granitic ridges to the east and north. It is roughly at the center of the 10 HFU contour, as defined by Combs (1975, 1976) see Figure 2.4.1-2. Highest temperature in the well (382°F) was encountered in a fracture zone at 1900 feet (Galbraith, 1978). Lost fluid circulation and hole deviation from vertical were recurrent problems during drilling.

Two flow tests of CGEH No. 1 were performed by Lawrence Berkeley Laboratory (LBL) in the Fall of 1978 (Goranson and Schroeder, 1978). Flows of less than 5 gpm were reported from these tests. An obstruction in the well at 4500 feet implies that the well cannot be used below this interval.

It is not known whether the low production is due to low permeability in this portion of the reservoir or due to plugging of the permeable zones by the copious amounts of mud that were injected during drilling to prevent loss of circulation. DOE abandoned the well shortly after the LBL flow test.

Exploration Geophysics

Exploration geophysical techniques are employed to detect anomalous conditions indicative of a geothermal reservoir at depth, to define its limits and to define target areas for deep exploratory drilling. Techniques used at Coso include heat flow, shallow ground temperature, seismic ground noise, electrical resistivity, gravity and low altitude aeromagnetics. The geophysical anomalies defined in these surveys generally coincide, lie within the 10 heat flow units (HFU) contour and converge around the active thermal manifestations of the region (Figure 2.4.1-2). Together, the geologic, geochemical and geophysical data indicate the possible extent of the geothermal system at Coso.

2.4.1.4 Seismicity

The CGSA lies near several of the most seismically active areas of California. Large active fault systems within 100 kilometers of the Hot Springs include the Owens Valley fault zone (about 20 miles north), the southern Sierra Nevada fault zone (about 10 miles west), the Panamint Valley fault zone (about 30 miles east), the Furnace Creek - Death Valley fault zone (about 55 miles east) and the Garlock fault zone (about 40 miles south (Figure 2.4.1-1). Smaller active faults which lie within the CGSA include the Haiwee Spring - Coso Hot Springs - Airport Lake fault zone and the Little Lake fault. Microearthquake patterns infer a north-northeast trending seismically active zone of crustal spreading (Weaver and Hill, 1978/79; Walter and Weaver, in press).

Earthquake History

The southern Sierra Front and surrounding area is characterized by a high level of strain release (Allen, et al, 1965), microseismic activity, and generation of several large to moderate magnitude earthquakes. More than 10 events of magnitude 5 to 5.9, two of magnitude 6 to 6.9 and one of magnitude 8+ have occurred within 62 miles of the study area since 1872.

Figure 2.4.1-3 shows the location of earthquakes occurring from 1900 to 1974 reported by the California Division of Mines and Geology, California Institute of Technology and the National Oceanic and Atmospheric Administration (Real, et al., 1978) with the location of the 1872 Owens Valley earthquake added. Events prior to 1930 are located mainly from reports by people who felt the earthquake in specific areas. Most earthquakes occurring after 1932 are instrumentally located.

The areas of highest seismicity within a 100-kilometer radius of the Coso Hot Springs are in Owens Valley and the Sierra Front southeast of Little Lake. The great 1872 earthquake and another large reported earthquake in 1790 were located in Owens Valley (Coffman and von Hake, 1973). A series of magnitude 5 to 6 earthquakes occurred southeast of Little Lake in 1946 (Real, et al., 1978).

Microseismicity

CGSA is an area of high seismic activity, occurring in swarm-type sequences and with relatively shallow hypocenters. A survey by Combs (1975) was of limited scope and duration. Additional data provided by a longer term, more comprehensive study conducted by Walter and Weaver (in progress) lead to different conclusions than those indicated by the Combs (1975) study.

The Walter and Weaver (in press) study revealed an apparent belt of seismicity trending northwest-southeast from Haiwee Reservoir to Sugarloaf Mountain, then south toward China Lake. Focal depths were generally from 4 to 8 kilometers. Historic data also infers a northwest trend of seismicity in this region. Seismic activity has been variable with very high levels (more than 100 events per day) to lower levels from month to month. However, some areas, such as

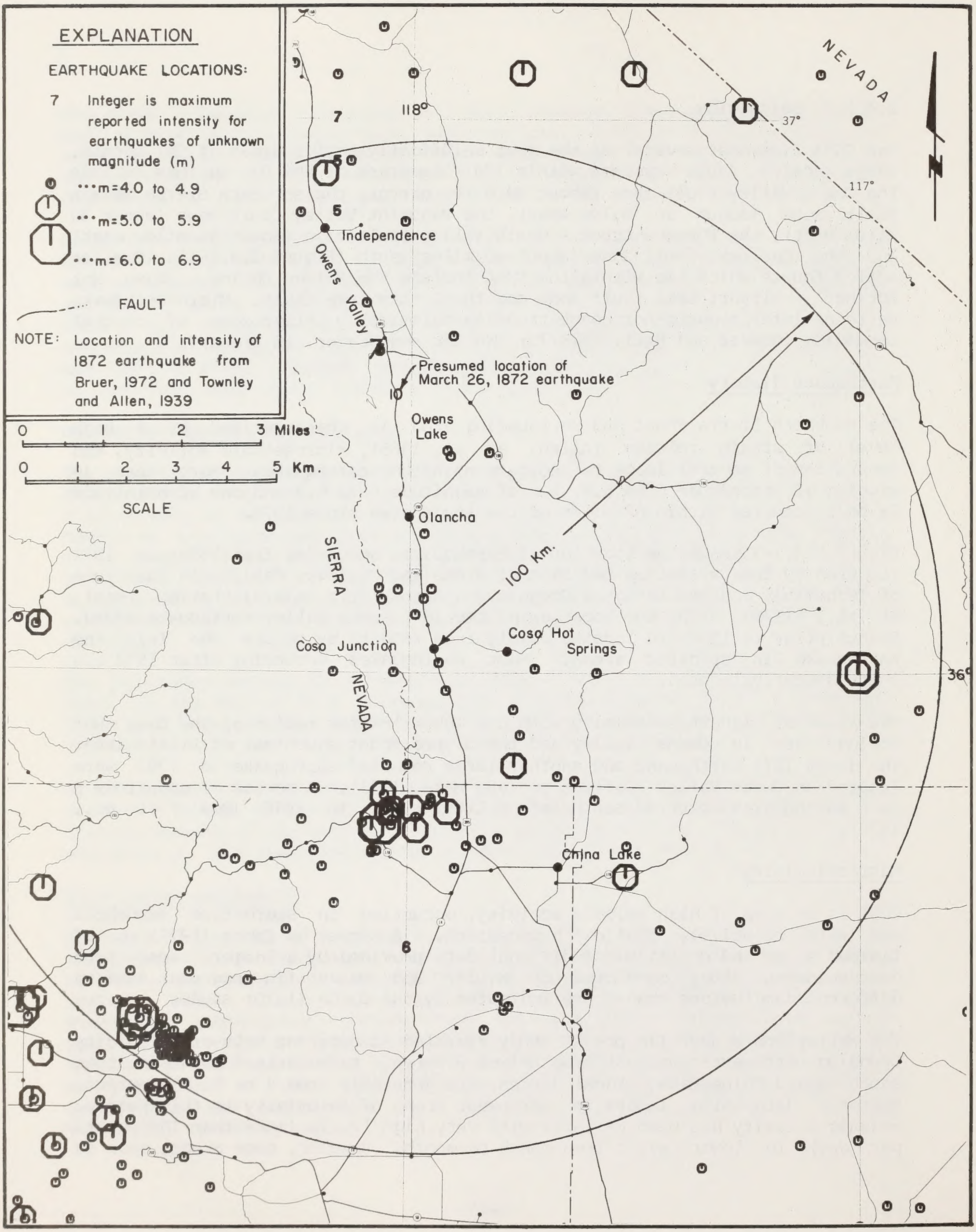


Figure 2.4.1-3 Historic Seismicity for the Coso Area, 1900-1974, (with location of 1872 earthquake) (modified from Real, et al.,1978)

Sugarloaf Mountain, were recurrently active. Focal mechanisms of microearthquakes are both strike-slip and dip-slip. The predominant trends are north-northeast trending dip-slip, northwest-trending, right lateral strike-slip, and northeast-trending left-lateral strike-slip. No mappable surface faults were correlated with microseismic activity. Earthquake swarms were noted around Sugarloaf Mountain, as they were during the Combs (1975) survey. However, in disagreement with the Combs survey, no clustering of events shallower than 2 kilometers was noted around active thermal areas.

2.4.2 Impacts of the Proposed Action on Geology

Potential geologic impacts can be divided into two general categories:

1. Geologic constraints on development activities due to geologic hazards. These include landslides, seismic shaking, surface faulting, ground failure and weak soils.

2. Impacts resulting from large scale fluid production and injection. This could include changes in seismicity patterns, land surface deformation and renewed volcanism.

2.4.2.1 Geologic Constraints

Seismic Hazards.--Earthquake associated damage can result from surface fault rupture, strong ground motion (shaking), ground failure induced by earthquake shaking (landsliding, settlement, liquefaction) or any combination of these effects. The great majority of earthquake damage is caused by strong ground motion and the geologic hazards in the CGSA will largely be those associated with earthquake shaking. Such damage, in improperly designed facilities, would include any type of structural failure such as well or pipeline failure, structural damage to building, cracking in paved roads etc.

The Coso region is seismically active. There are several major active fault zones within 50 miles (Figures 2.4.1-1 and 2.4.1-3). Some are within the CGSA boundary, including the Haiwee Spring, Coso Hot Springs, Airport Lake, and Little Lake. The study area could experience significant ground shaking from a major earthquake on any of these local or regional fault zones. Generalized shaking characteristics of expected earthquakes are presented on Table 2.4.2-1. The seismic zones specified in this table are shown on Figure 2.4.2-1. These ground motion characteristics and seismic zones may be used for general planning purposes. However, to determine specific ground shaking parameters for critical structures, individual site and structure analysis will be required.

Table 2.4.2-1
Generalized Characteristics
Of Expected Earthquakes

Zone	Maximum Ground Acceleration (g's)	Predominant Period (Seconds)	Duration of Strong Shaking (Seconds)
IA	0.13	0.3-0.8	8-15
IB	0.13	0.2-0.4	5-10
IIA	0.26	0.3-0.8	10-25
IIB	0.26	0.2-0.4	8-15
IIIA	0.40	0.3-0.8	15-35
IIIB	0.40	0.2-0.4	10-20
IVA	0.53	0.3-0.8	20-45
IVB	0.53	0.2-0.4	15-25

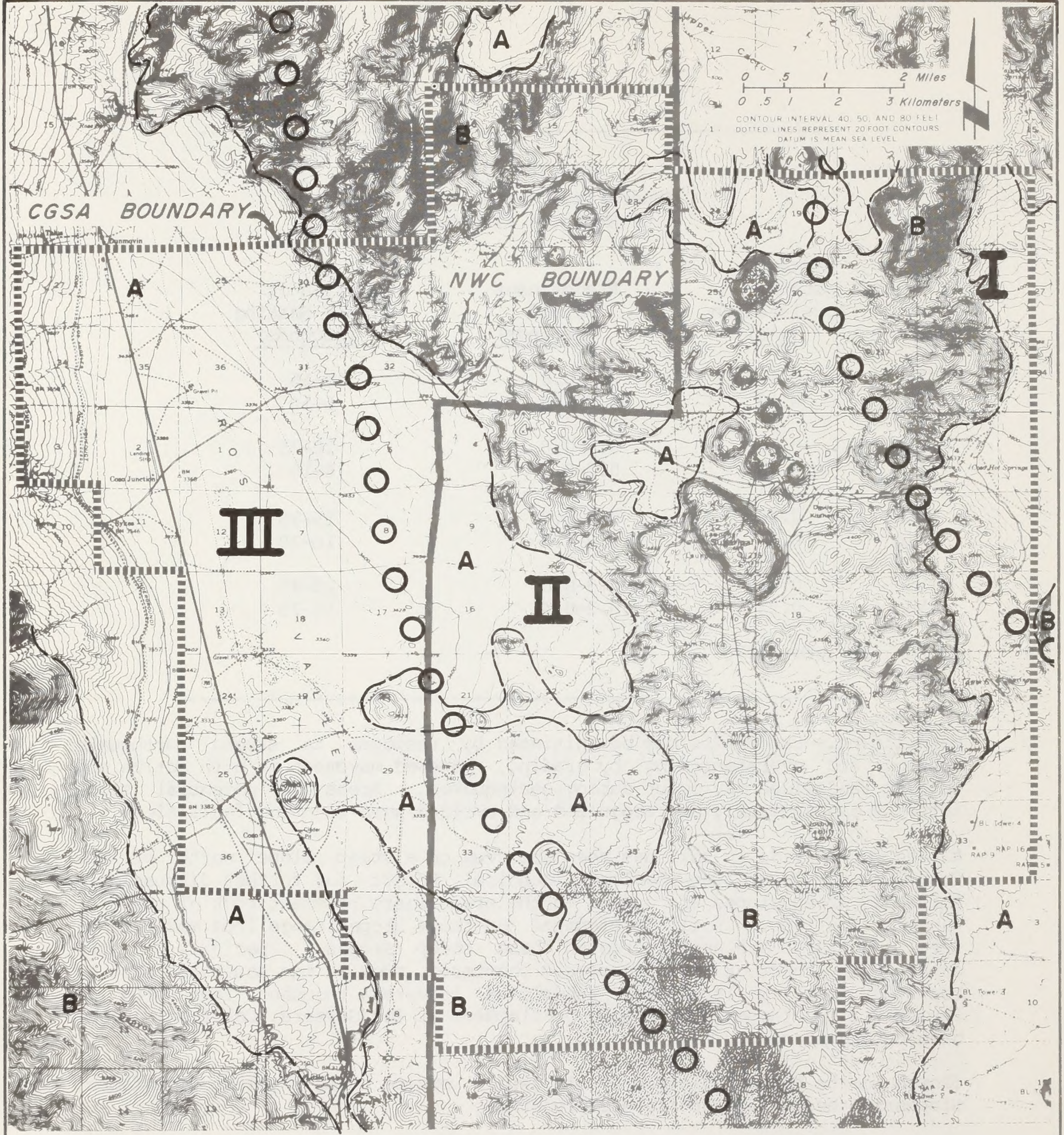
Source: Envicom, 1976

Landsliding.--Landslides may be initiated by response to strong earthquake shaking and oversteepening by grading. Renewed movement on both active and ancient landslides may occur during earthquakes. Areas of potential slide activity can generally be recognized and avoided when locating facilities.

A rotational slide in soil has been observed on a steep slope north of the Coso Resort Area (see Geology Technical Report for further discussion). Naturally steep slopes are common in the areas where basement rock of the Coso Range crops out. Soil development on these slopes range from moderate to deep. Rockfalls are anticipated on these steep slopes, especially in the areas where bedrock is pervasively shattered, such as the southeast part of the study area. No large-scale landslides (several thousand feet plus in length) like those which plague development at The Geysers, California, have been observed.

Slopes in the pyroclastic debris are gentle, except along rhyolite dome faces. Slopes in these areas are relatively stable.

Surface Faulting.--Several active faults exist in the CGSA. Some of these are associated with the surface thermal manifestations at Coso Hot Springs. While there is always some possibility of future faulting in any locality in a seismicly active region, the historical occurrences of surface faulting have generally closely followed the trace of existing recently active faults.



EXPLANATION

(See Envicom, 1976 for detailed explanations, limitations and locations)

I O / O II *Seismic Zone boundary, based on 500 year earthquake and distance to causative fault*

A/B *Ground shaking zone boundary, generalized and approximately located; A = Alluviul areas, B = Bedrock areas.*

Figure 2.4.2-1 CGSA Seismic Zones (after Envicom, 1976)

Therefore, future surface faulting or rupture is most likely to occur on known active traces of faults in the study area.

Other Ground Failure Induced by Shaking--Settlement or densification may occur in sandy soils above the ground water table or earth filled areas during earthquake loading due to rearrangement of particles. A potential for earthquake induced settlement exists in alluvial areas.

Liquefaction occurs only in cohesionless soils where the water table is high. It is not expected in most parts of the CGSA because of deep ground water conditions. However, seasonal perched shallow ground water has been noted in the valley area between Devil's Kitchen and Coso Hot Springs.

2.4.2.2 Land Surface Deformation and Renewed Volcanism

The possibility of triggering earthquakes by geothermal production and injection is of some concern. Although existing producing fields at The Geysers, California, and Wairakei, New Zealand have long been associated with pre-existing earthquake activity, no associations have been drawn between geothermal production and induced earthquake activity.

Existing oil field and waste well data have yielded clues to the effect of fluid injection on triggering earthquakes. Of the thousands of existing oil fields and waste injection wells, only a few instances of earthquake triggered by fluid injection have been sited in the literature. One of them is at the Rocky Mountain Arsenal waste disposal well near Denver, Colorado and another is at the Rangely Oil Field in northwestern Colorado (Raleigh, et. al. 1976). The largest event registered at Rangely was a magnitude 5 earth quake. Earthquakes are inferred to be caused by an increase in pore pressure that results in shear failure, therefore reducing the normal stress across fracture surfaces. However, regional tectonics, the stress field and rock properties in other areas are different from Rangely, so the Rangely experience may not apply universally to all injection programs.

Withdrawal of geothermal fluids may alter deep ground water flow patterns. The effect of these alterations on the tectonic stress regime is unknown.

Two criteria can be considered useful in detecting induced earthquakes: changes in frequency-magnitude statistic in the area of the geothermal field; and changes in depth and location of events from pre-production activity (Phelps and Anspaugh, 1976). It will require several years of continous monitoring activity, superimposed on the known background seismicity, to understand the possible effects of withdrawal and injection of fluids on seismicity.

Ground subsidence is the most common and obvious type of land surface deformation, although horizontal movements are also possible. It occurs with the withdrawal of large amounts of fluid (oil, gas, steam or water) and subsequent compaction of compressible or poorly consolidated sediments. Since the geothermal resevior rocks at Coso are the strong, fractured, crystalline basement rocks of the Coso Range and spent fluids will be reinjected, subsidence in the producing geothermal field is not anticipated.

Extensive withdrawal of ground water in Rose Valley will cause a drop in the ground water level as discussed in Section 2.5.2. Many ground water basins throughout the world have experienced ground subsidence from extensive, long-term overdraft of the ground water resevoir. (Bouwer, 1978, p. 314). Subsidence could occur in Rose Valley with extensive long-term overdraft of the ground water resevoir. Effects would be minimal due to the sparse development of the field. The Los Angeles Aqueduct is located on the alluvial fans in the western margin of the valley and would most likely be out of the zone of potential subsidence. The Southern Pacific Railroad is simularly located in the northern half of the valley, while in the southern portion the railroad runs along the valley floor. However, ground water pumping, and subsequent possible subsidence would most likely occur in the east-central part of Rose Valley, closer to the development area.

Renewed volcanism poses little hazard (Inyo County Planning Department, 1979). The effects of large scale geothermal fluid withdrawal on volcanism are presently not possible to predict. However, it is not anticipated to effect potential volcanic activity.

2.5 HYDROLOGY

2.5.1 Present Hydrologic Environment

2.5.1.1 Surface Water

The CGSA is located in the northern Mojave Desert, encompassing Rose Valley, Coso Basin, and several smaller enclosed basins located between Rose Valley and Coso Basin (Figure 2.5.1-1 and Plate 2.5-1 of the Hydrology Technical Report).

Watershed Features.-- The drainage areas of Rose Valley, Coso Basin, and the enclosed basins are shown in Table 2.5.1-1.

Table 2.5.1-1
Areas of Watersheds in the CGSA

Watershed	Area: Acres	Area: Square Miles
Rose Valley	89,640	140.07
Coso Basin	132,750	207.42
Upper Cactus Flat	10,350	16.18
11 Enclosed Basins	6,690	10.45

The Coso Basin encompasses a major portion of the Coso Range. The crest of the range serves as the eastern and northern boundaries of the basin. The enclosed basins are bounded by the lower Coso Range.

The soils and vegetation in the CGSA are significant factors contributing to the high runoff potential of upland watershed areas of Rose Valley, Coso Basin, and the enclosed basins. The principal runoff producing areas are the uplands of the Sierra Nevada and the Coso Range, characterized by shallow soils, exposed bedrock and sparse vegetation with reletively high runoff potential. The soils and vegetation of the CGSA are capable of retaining the moisture from most low-intensity precipitation events.

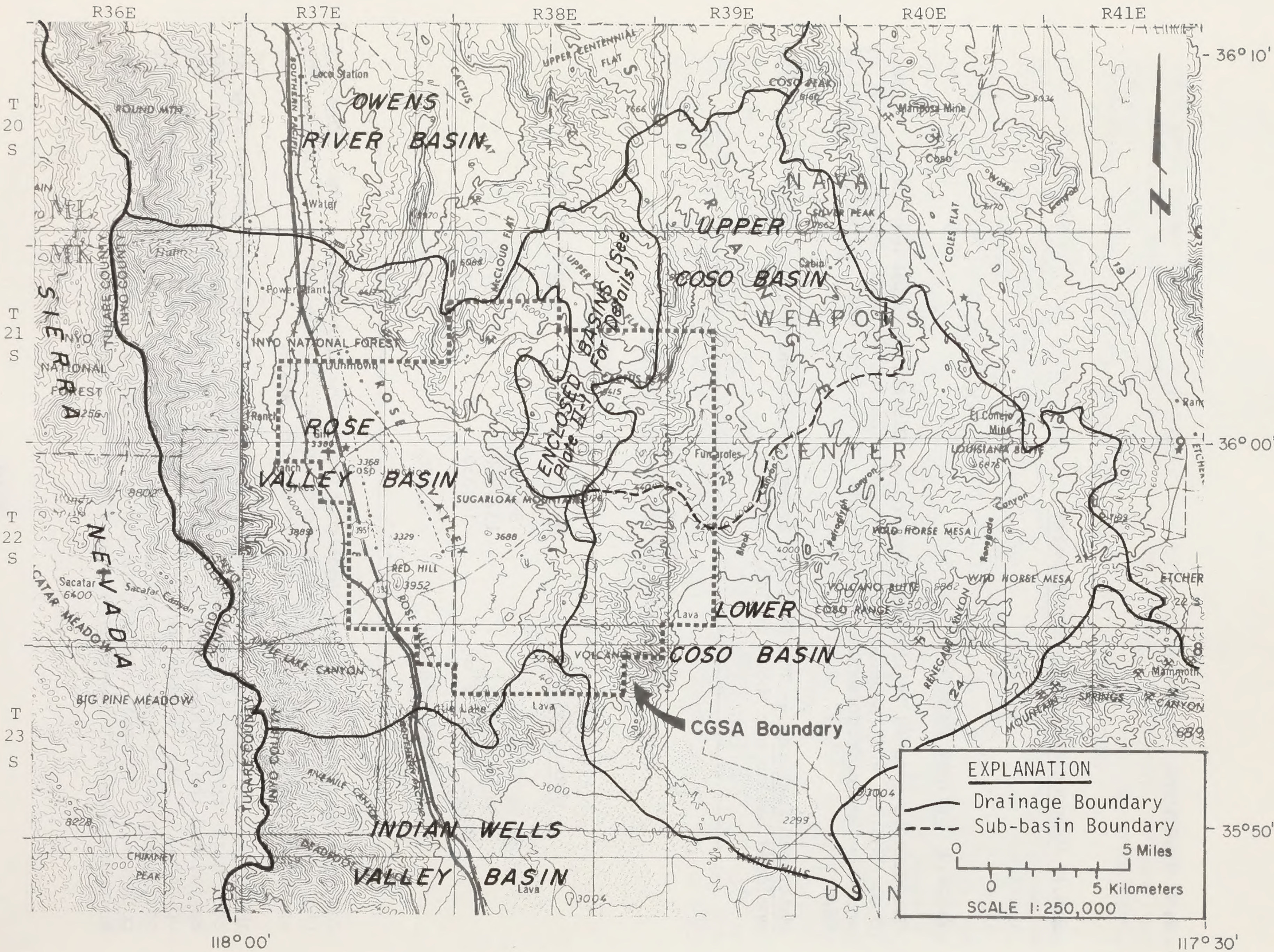


Figure 2.5.1-1 Watershed Boundaries - CGSA

Flow Regime--Surface water flow in the CGSA is predominantly ephemeral streamflow. Minor amounts of perennial streamflow exist in the Sierra Nevada in response to snowmelt at the upper elevations. The ephemeral surface water flow is primarily a function of the low frequency of precipitation. Surface runoff that does not infiltrate ultimately reaches playas where it evaporates. Voluminous short-term runoff occurs mainly on large, less permeable steep sided washes.

Rose Valley drains southward toward Indian Wells Valley at Little Lake. All streams originating in the Sierra Nevada and ephemeral streams originating in the Coso Range drain toward Rose Valley. Only in years of unusually high precipitation will streams flow onto the valley floors all or most of the year. Most of the water infiltrates into the alluvial fans or is trapped in small playas before reaching Little Lake. The perennial streams terminate before reaching the valley floor. Several small perennial and ephemeral springs discharge at the base of the Sierra Nevada.

Little Lake, an emergent underflow lake, is the only perennial surface water body in Rose Valley. There is minimal surface discharge from Little Lake into Indian Wells Valley. It is a flat-bottomed spring-fed lake of about 100 acres. When its level is low, two wells (23S/37E-8D1 and 8D2) pump water into it. In the Spring of 1979 it was near its highest level, up to 5 feet deep and averaging 3-1/2 feet. During the dry year of 1976 it was about 3 feet lower (Bate, 1979, personal communication).

Little Lake is in a remnant of a former Owens River channel. It was much smaller prior to construction of a dam, and may be a sag-pond type feature associated with the northerly trending pre-Quaternary Little Lake fault (Plate 2.5-1 in the Hydrology Technical Report). This fault may be a ground water barrier and, in conjunction with the basement complex approaching the surface near Little Lake, may serve as a water trap.

Coso Basin drains internally into Airport Lake on the south. No perennial water occurs here. The enclosed basins in the Coso Range drain internally into small depressions and playas. Numerous springs flow on the east slope of the Coso Range. Perennial fumaroles and hot springs exist at Coso Hot Springs and Devil's Kitchen. Airport Lake, a large playa contains water only after heavy rainfall, which is lost by evaporation, and possibly by a minor recharge to ground water.

Runoff.— The surface hydrology of a desert area is greatly influenced by the precipitation patterns. Other major factors influencing the behavior of surface water are: soils, topography, and vegetation. Precipitation in the Mojave Desert is produced by three types of storms: general-frontal, convective, and tropical. The general-frontal storm is a low-intensity, long-duration event, which usually results in minor surface runoff. The infiltration capacity of soils and interception capacity of vegetation are generally able to retain the precipitation. The convective storm is a high-intensity, short-duration event having limited areal extent, which can produce large amounts of highly localized runoff. Generally, the intensity of convective storms exceeds the infiltration capacity of the soils. Tropical storms come from the incursion of moist, warm air from the south, which produces prolonged, steady, torrential rains. They cause high infiltration and severe runoff. Larger precipitation events probably occur when convective activity takes place within a large frontal storm system.

The CGSA is arid to semi-arid, surface flow occurs on a relatively rare basis, (see Table 2.3 in the Hydrology Technical Report). This requires that the surface water hydrology be evaluated on an event basis as well as an annual basis.

Average annual runoff is about 2 inches for Rose Valley, Upper Coso Basin and Upper Cactus Flat. It is somewhat lower for Lower Coso Basin and the enclosed basins. (See Table 2.3, Hydrology Technical Report.) About 70 percent of the average annual precipitation occurs between November and March. The annual runoff estimates were influenced greatly by the large variation observed in annual runoff data. It is questionable whether annual runoff statistics can be used to accurately describe the nature of surface water runoff in arid areas.

Event-based analysis can pinpoint the effects of extreme hydrologic occurrences. Such analysis is essential to the hydrologic evaluation of the CGSA.

The 100-year design storm was chosen for analysis as the extreme precipitation occurrence. Estimates of surface runoff and peak discharge were made using the hydrologic model, HYMO (Williams and Hann, 1972). The results are shown in Table 2.5.1-2. In general, the 6-hour storm produced larger peak flows than the 24-hour storm. The principal effects of the 6-hour storm are due primarily to the peak discharge. The effects of the 24-hour storm are due primarily to the total volume of runoff.

Table 2.5.1-2
Estimates of Runoff from CGSA Watershed
For the 100-year Design Storms

24-Hour Storm

	Precipitation in.	Runoff in.	Runoff AF	Peak Discharge cfs
Upper Rose Valley	5.90	4.22	30730	20051
Lower Rose Valley	5.90	2.07	378	258
Upper Coso Basin	4.50	3.28	11250	7354
Lower Coso Basin	3.80	2.74	20718	32143
Upper Cactus Flat	4.50	3.36	2899	2025
Enclosed Basins				
A	4.50	0.43	26	19
B	4.50	0.09	2	1
C	4.50	2.29	731	532
D	4.50	0.26	6	4
E	4.50	0.62	52	38
F	4.50	0.00	0	1
G	4.50	1.03	117	85

6-Hour Storm

	Precipitation in.	Runoff in.	Runoff AF	Peak Discharge cfs
Upper Rose Valley	2.11	0.88	6391	21095
Lower Rose Valley	2.11	0.88	161	939
Upper Coso Basin	1.90	0.95	3250	12904
Lower Coso Basin	1.46	0.65	4939	14782
Upper Cactus Flat	2.41	1.15	989	5616
Enclosed Basins				
A	2.41	1.08	66	670
B	2.41	0.46	8	80
C	2.41	1.04	334	2315
D	2.41	0.79	17	182
E	2.41	1.07	88	806
F	2.41	0.15	1	12
G	2.41	1.06	120	954

The surface water runoff resulting from the design storms will move through the watersheds as described in Section 2.5.1.1. However, a significant portion of the runoff may be lost as channel infiltration. Runoff from Upper Rose Valley will flow to playas and eventually into Little Lake. Little Lake will behave in a manner similar to a reservoir, storing some water as lake levels increase and Discharging water via the south end. The runoff eventually discharges into Indian Wells Valley, approximately 31,000 AF from the 24-hour storm or 6500 AF from the 6-hour storm. Runoff from Upper Coso Basin will flow down Coso Wash into the Lower Coso Basin and combine with runoff from the Lower Coso Basin. The runoff accumulates in Airport Lake - approximately 32,000 AF from the 24-hour storm or 8,200 AF from the 6-hour storm. The runoff in the enclosed basins terminates in playas.

The existence of Haiwee Reservoir presents an extreme hydrologic condition not normally considered in an event-based analysis. Estimates of the potential inundation of Rose and Indian Wells Valleys due to failure of the dam are shown in Appendix D of the Hydrology Technical Report.

Surface Water Quality and Erosion

The quality of surface water in the CGSA is influenced by the type of runoff. The principal difference in water quality resulting from frontal and convective storms is suspended sediment; convective storms carry more sediment.

Water quality data are difficult to obtain due to the infrequency of runoff events in the CGSA. The locations of surface water sampling points are shown on Plate 2.5-1 in the Hydrology Technical Report. Chemical analyses for typical surface runoff and surface water bodies are presented in Table 2.5.1-3. Chemical characteristics of surface runoff from the Sierra Nevada and Coso Range are consistent. Water from the surface water bodies, Airport Lake and Haiwee Reservoir, has lower specific conductance (is less mineralized) than streamflow water.

Airport Lake is probably representative of the water quality of surface runoff in the Coso Basin. In arid areas, sediment is often the most important water quality parameter. Consequently, the sample from Airport Lake was analyzed for total suspended solids (TSS). A TSS value of 104 mg/l was determined using a 5-10 micron glass fiber filter and a TSS value of 3170 mg/l was determined using a 0.45-micron filter. The value of 3170 mg/l is characteristic of the fine suspended sediment found in the playa waters.

Erosion

Major runoff events can mobilize large amounts of sediment, particularly on steep slopes. In the CGSA, sheet erosion and wind erosion produce only minor sediment yields relative to channel erosion (Glosser, 1979). The undisturbed soils in the CGSA are fairly stable and not susceptible to significant amounts of sheet erosion. The principal cause of upland erosion in the Coso Range is wind.

Table 2.5.1-3 Chemical Analyses for Typical CGSA Waters

	Nonthermal Wells			Thermal Wells				Surface Waters	
						CGEH-1	Haiwee Spring	Portuguese	Little
Name/Number	21S/37E-2K1	21S/37E-26B1	23S/38E-5N1	22S/39E-4K1	22S/39E-4K2	22S/39E-6G2	21S/37E-10PS1	Canyon	Lake
Date of Sample	1975	12/78	3/60	12/77	9/78	12/77	4/79	2/79	4/79
Source[a]	M	P	M	S	N	F	H	H	H
Units	mg/l	ppm	mg/l	ppm	mg/l	mg/l	mg/l	mg/l	mg/l
Temperature - ^oC	14.0	---	---	91.2	---	---	---	---	---
pH	7.8	7.78	8.0	6.92	2.5	8.14	8.2	8.28	8.8
Specific conductance (mho)	1340	1130	1420	240	---	---	430	446	1600
TDS - sum	878	716	1163[c]	185	1757	5610	285[b]	385	1045[b]
Ca	52	67	49	6.4	42	93.0	38	57.4	52
Mg	28	22	31	0.25	18	2.7	13	10.6	60
Na	220	99	225	33	420	1590.0	29	18.0	200
K	8.0	14	12	5.9	73	126.0	6	5.8	24
HCO_3	150	200[d]	513	12	0	279.0	143	238	497
CO_3	---	---	0	---	0	---	6	---	69
SO_4	370	200	93	83	1000	245	73	23.4	158
Cl	50	66	170	1.7	21	2480.0	16	13	112
SiO_2	40	32	48	42	93	710.0[e]	---	19.0	---
Others	Fe = 0.2 F = 0.9 NO_3 = 1.2 N = 0.03 NO_2 = 0.12 NH_4 = 0.0 PO_4 = 0.60 As = 0.59 B = 1.3	B = 1.4 Li = 0.0 NH_4 = 0.0 NO_3+ NO_2 = 15 F = 0.0	F = 0.7 NO_3 = 9.3 B = 4.0 CO_2 = 8.2	F = 0.4	NH_4 = 73 NO_2 =<0.1 NO_3 = 1.0 F = 0.1 As = < 0.01 B = 0 PO_4 = 65.7 Cu = 0.4 Br = 0.0 Hg =<0.001	F = 3.8 B = 56.0 Li = 10.0 Rb = 0.118 Cs = < 0.01	F = 0.4 B = 0 NH_4 = 0.2 OH = 0 NO_3 = 1		F = 1.4 B = 6 NO_3 = 2 OH = 0 NH_4=0.4
Anions/cations (epm)	0.79	0.91	1.00	0.96	0.95		1.02	0.98	1.00

a M = Moyle, 1977; P = P. Hennis (personal communication, 1979); R = R. Lane (personal communication, 1979); S = Spane, 1978; N = Naval Weapons Center (personal communication, 1979); H = Hydrology Technical Report; F = Fournier, et al., 1978

b TDS residue on evaporation at 180^oC

c Recalculated from original source

d Value is for HCO_3+CO_3

e Silica values include possible colloidal clay dispersed in water

Wind erosion is most prevalent during the non-vegetative period of the year (October to May). The wind-eroded materials are generally deposited in stream channels, which further increases the potential for stream channel erosion.

Channel erosion and sediment transport are governed by the amount and duration of runoff and degree of channel development (Water Management Subcommittee, 1968). Frontal storm runoff generally produces minor channel and upland erosion, while convective storm runoff produces relatively great channel and upland erosion. Frontal storms with associated convective activity produce long-duration high flows, necessary for maximum sediment transport. Storms of this nature are characteristic of the CGSA. The amount of runoff and subsequent erosion are greatly reduced by infiltration to the stream-bed. The porous materials in the stream beds in the CGSA are capable of sustaining large stream bed losses during runoff periods.

2.5.1.2 Ground Water

Hydrologic Units

Hydrologic units are traditionally divided into two major categories: (1) non-water-bearing units, and (2) water-bearing units. The major water-bearing unit in the CGSA is the Quaternary alluvial sediment. The fractured granitic and metamorphic areas of the Pre-Tertiary basement complex, the Tertiary and Quaternary volcanic areas and the Tertiary Coso formation are not considered water-bearing units (Dutcher and Moyle, 1973, p.8).

The areal distribution of these units is shown on Plate 2.4.1 in the Geology Technical Report.

Since acquifer test data and ground water basin development are extremely limited to the CGSA, estimates of the hydrologic characteristics are based largely on the characteristics of analogous lithologic units in nearby areas.

Thickness of Alluvial Deposits--Estimated thickness of alluvium in Rose Valley was interpreted from gravity data (Healy and Press, 1964) with geophysical and geologic borehole logs for control in a few areas. Maximum valley fill thickness reaches 5600 feet (Healy and Press, 1964) in the north-central part of the valley. It has been suggested that interpretation of additional gravity data may reduce the maximum alluvial thickness estimate to about half of the present estimate (Moyle, 1979, personal communication). Interpretation and inclusion of these additional data would increase the confidence of the present estimate and structural interpretation.

Transmissivity--Transmissivity is an expression of the capacity of the aquifer to transmit water. The coefficient of transmissivity is defined as the quantity of water that will flow through a 1-foot-wide vertical strip including the total thickness of the aquifer under a hydraulic gradient of 1 foot per foot. It is expressed in gallons per day per foot (gpd/ft). The coefficient of transmissivity of saturated alluvium in Indian Wells Valley ranges from over 300,000 gpd/ft in the central parts of the valley to about zero at the basin margins (Dutcher and Moyle, 1973, p. 11). Transmissivity in Rose Valley can be expected to be similar.

Ground Water Movement

Very few water level data are available for the CGSA. However, compilation, interpretation and extrapolation of all data suggests ground water flows into Rose Valley from the west, with perhaps some component from the north and east.

Two cross-sections were constructed from the geologic and hydrologic data: one trending east-west (Figure 2.5.1-2), the other trending north-south (Figure 2.5.1-3).

Interpretation of these cross-sections imply:

A. The major component of ground water flow is from west to east from the Sierra, and the Sierra Nevada fault zone apparently acts as a ground water barrier.

B. The configuration of schematic ground water contours (Section 3.2.1, Hydrology Technical Report) suggests an east to west component of flow from the Coso Range into Rose Valley. If this is true, then there is hydraulic connection between the geothermal reservoir and the ground water in Rose Valley. Alternatively, a ground water barrier prevents flow between Rose Valley and the geothermal reservoir. Presently there is not enough water level elevation data to determine which of these interpretations is correct.

Ground Water Flow in the Coso Range--There are several hypotheses for ground water movement in the Coso Range, particulary with respect to recharge of the geothermal reservoir. Implications that can be drawn from Figure 2.5.1-2 are:

A. CGEH-1 and Coso No. 1 are in hydraulic communication.

B. The water table in the Coso Range is essentially horizontal at 3460 feet.

C. If the water table is relatively flat, as (B) implies, then there is either very good hydraulic conductivity within the reservoir or the fluid has had a long time to equilibrate.

The fact that the water table appears higher in the Coso Range than in Rose Valley suggests that the reservoir is not being recharged from the Sierra. If there is no hydraulic barrier between the Coso Range and Rose Valley, then ground water would flow from the geothermal reservoir into Rose Valley. This

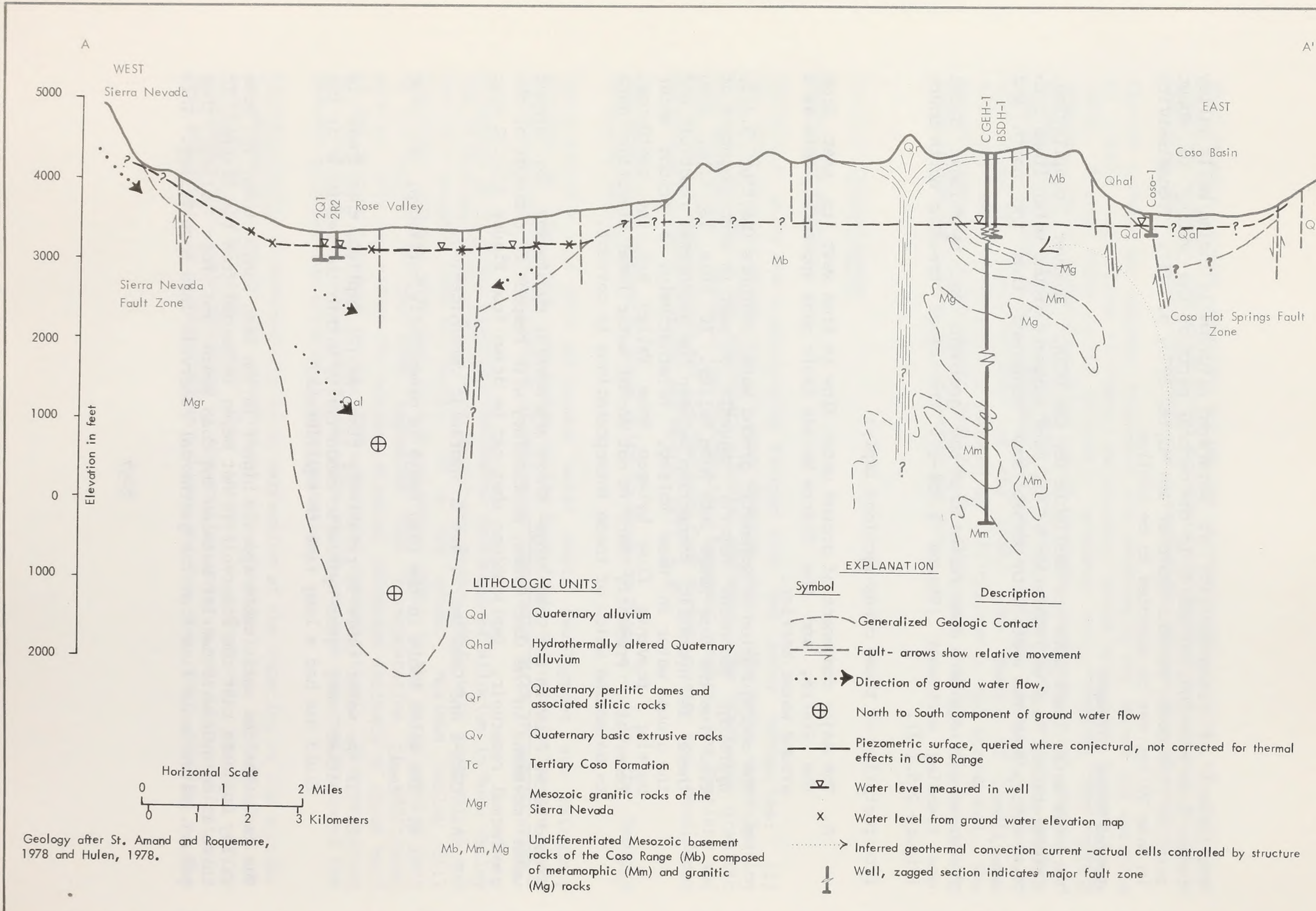


Figure 2.5.1-2 EAST-WEST SECTION ACROSS THE CGSA

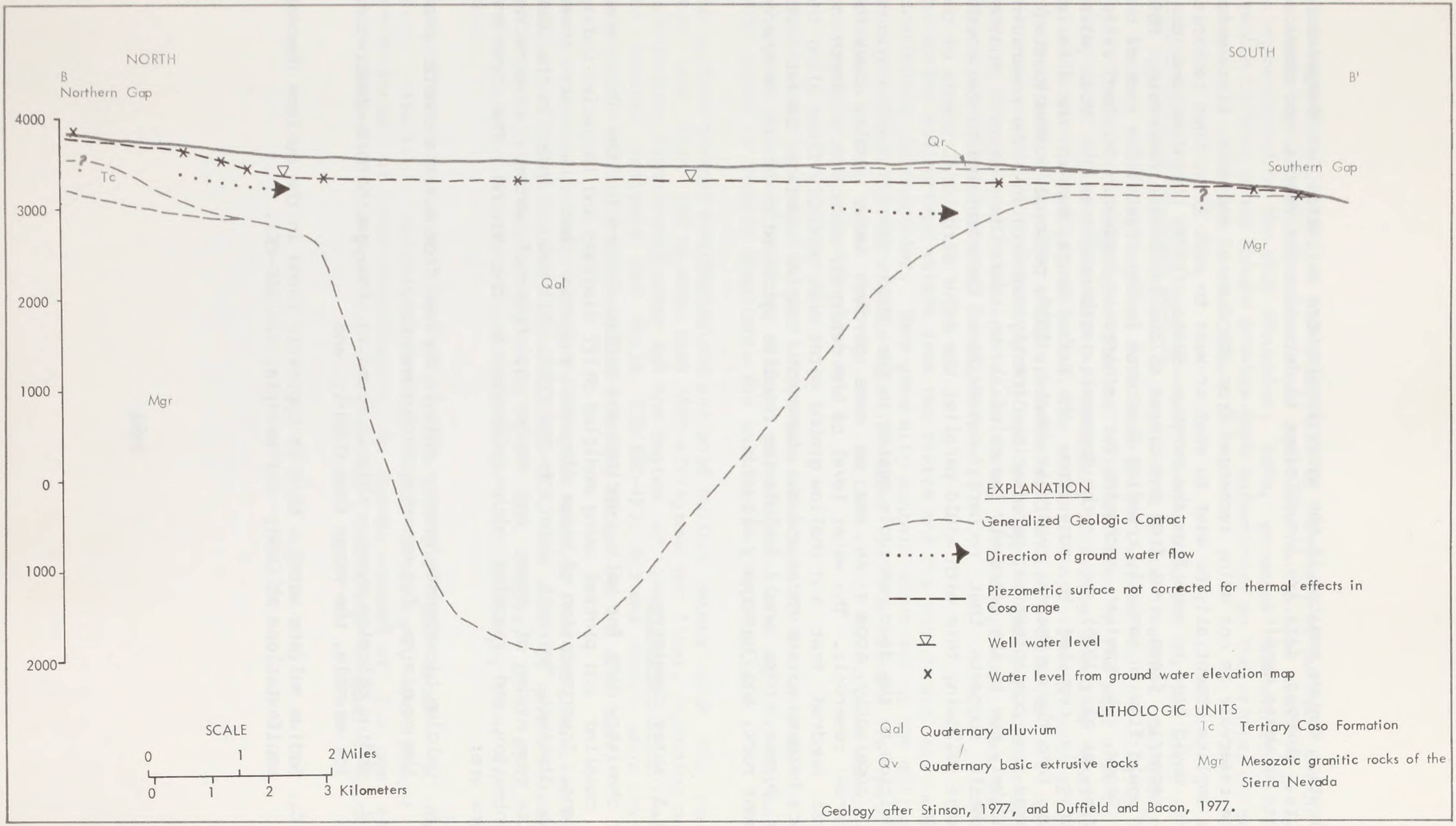


Figure 2.5.1-3 NORTH-SOUTH SECTION ACROSS ROSE VALLEY

implication may be negated if the water levels were corrected for temperature effects. However, data are insufficient to determine the thermal and chemical effects on water density.

If the reservoir is not being recharged from the Sierra and the flat water table implies essentially no east to west or west to east flow, then recharge, if any, would have to come from the north. Spane (1978) hypothesizes that deep recharge flows east from the Sierra to the geothermal reservoir. This water would flow in easterly trending fractures in the crystalline rock of the Coso Range. A similar mechanism for recharge is suggested for Long Valley (Fourier, et al., 1978) and for the Roosevelt geothermal area in Utah where recharge is reported to come from the Tushar Range, beneath the alluvial valley, into the geothermal reservior (Whelan, 1979, personal communication). Recharge from precipitation, percolating directly downward into the reservoir, is unlikely due to the extremely low rainfall on the Coso Range. Another hypothesis suggests that recharge comes from the mountains to the north. Recharge following this path would parallel the major structural trends of the region.

In addition to the deep reservoir system in the Coso range, shallow ground water apparently occurs as one or more perched water tables above the geothermal reservoir. The water level of the reservoir occurs at a depth of several hundred feet and shallow ground water most probably flows along the contact between porous rocks and the basement complex surface beneath it. These porous rocks would include the rhyolite pyroclastic debris, weathered basement rock, and Quaternary alluvium.

2.5.1.3 Water Chemistry

Water chemistry data for wells, springs and surface waters in the Coso area were compiled and plotted using modified Stiff diagrams and Langelier-Ludwig diagrams. Interpretation of these diagrams suggests that there are three fairly distinct "parent" waters in the CGSA. All natural water in the CGSA results from mixing of three end member or "parent" waters, evaporative concentration and reaction with sediments in the ground. The three end members are:

A. Calcium bicarbonate water - this is derived from surface runoff from the mountains, for example, Portuguese Canyon;

B. Sodium chloride water - this is found in the geothermal reservoir; for example, the water from CGEH-1; and

C. Sodium sulfate water - this is typically found in the surface thermal manifestations at Coso; for example, 22S/38E-4K1.

Additional data collection and study will be necessary to further define the relationships of different waters and aquifers. An isotope study is presently being conducted by the USGS (Fournier, 1979, personal communication). The results of this study should provide much information on the origin, movement, and genesis of waters in the CGSA.

Natural or Existing Water Quality--Most known ground and surface water in the CGSA appears suitable for domestic, agricultural and livestock use, except for the thermal waters and somwhat more mineralized waters in the Little Lake area. There are presently no chemical data for water on the east side of Rose Valley or at depth. These data are necessary to define baseline conditions. In addition to spatial variation, the chemical composition of natural waters will vary with time. For example, the several analyses included for surface thermal waters, for Haiwee Spring and Lewis Spring show some variation. In order to determine if natural water is being degraded, some idea of this natural variation must also be established.

The spring and surface waters from the Sierra and the Coso Range are calcium bicarbonate in character. They generally contain about 300 to 500 milligrams per liter TDS. The TDS of this type of water in the ground is generally somewhat greater than that in the surface runoff due to some evaporative concentration and solution of minerals.

Wells and surface water in the Little Lake area have TDS contents up to 1300 milligrams per liter or more. A boron concentration of 6 mg/l for the surface water makes it totally unsuitable for agricultural applications.

The surface thermal manifestations are acid sulfate waters with TDS ranging from less than 200 to more than 2000 milligrams per liter, depending on the contribution from ground water and the degree of evaporative concentration. The several analyses for Wells 22S/39E-4K2, 4K3 and others, show that the composition and concentration of hot spring waters varies with time.

Trace amounts of mercury were found in water samples from the Coso resort area (Austin and Pringle, 1970). Well 21S/37E-2K1, just south of Haiwee Reservoir, contained 0.59 milligrams of arsenic per liter (Moyle, 1977, p.47). The drinking water standard for arsenic is 0.05 milligrams per liter (U.S. EPA, 1976).

The geothermal reservoir fluid is a sodium chloride type water. It has a total dissolved solids content of about 5600 mg/l, and likely high concentrations of toxic constituents. An arsenic content of 7.5 ppm and a boron content of 71.6 ppm have been reported (Austin and Pringle, 1970, p.36).

2.5.1.4 Hydrologic Models

In the resource assessment stage, such as this, data are sufficient only for a simple, qualitative conceptual model of the system. Such conceptual models for the geothermal system and the cooler ground water system are outlined below. A conceptual model for volcanic geothermal systems in general is outlined in Section 3 of the Geology Technical Report.

Conceptual Model of the Geothermal System--The geothermal reservoir at Coso is in fractured granitic and metamorphic rocks. It is essentially a liquid dominated system with a boiling water table (Galbraith, 1978, p.22). The great number of fractures and the complexity of the fracture distribution may compartmentalize the reservoir. Evidence to date suggests that vapor dominated sections occur as steam above the boiling water table. Since there is no evidence of a continuous caprock at Coso there must be a low heat flux, deep water table (Galbraith, 1978, p. 22) and/or channel deposition partially filled by hydrothermal alteration products to account for the limited surface manifestations. The hydraulic properties, temperature and areal extent of the reservoir are described in Appendix B, and in the Geology Technical Report. To summarize, the hydraulic properties of the reservoir are based on the following assumptions:

A. The rock matrix of the reservoir has no primary porosity; no deep primary aquifers have been identified by drilling or geologic mapping (Hulen, 1978, p. 24);

B. All flow and storage is in fractures with direction of flow probably entirely structurally controlled (Hulen, 1978, p. 24);

C. The porosity will vary widely depending on the size and openness of fractures.

Based on heat flow studies (Combs, 1976) the eastern boundary of the reservoir appears to be well defined at the Coso Hot Springs fault. The western boundary appears to be gradational, with cooler parts of the reservoir extending into or under Rose Valley. The northern and southern boundaries extend several miles to the north and south, respectively, of the Devil's Kitchen area.

The fluid in the reservoir may be relatively static, circulating as convection cells, or part of a deep circulation system. It may originate from the Sierra to the west, the Coso Range or Owens Lake area to the north, a genetic source below (see Hydrology Technical Report), or some combination.

Test wells Coso No. 1 and CGEH-1 are about 2 miles apart and terminate at depths of 375 feet and 4794 feet, respectively. The marked similarity in composition of the reservoir fluid from these two wells suggests that convective currents within the reservoir may mix and "homogenize" the fluid.

Coso Hot Springs--The acid sulfate waters, such as those found at Coso Hot Springs, are distinctly different from the sodium chloride fluid found in the deeper reservoir. Acid sulfate waters, may be derived from steam condensing into surface waters. Oxidation of hydrogen sulfide to sulfate contributes to the acidity. Other constituents are leached mainly from rocks and sediments surrounding the pools (Ellis and Mahon, 1977, p. 60).

The Coso Hot Springs are not technically springs, but rather areas where steam condensate accumulates over near-surface impermeable clay layers (Austin and Pringle, 1970). The fluid levels, concentration, and temperature of the springs, all vary with precipitation, temperature and quantity of shallow ground water (Spane, 1978; Austin and Pringle, 1970). In the winter, when precipitation is greater, the fluid levels in the mud pots rise and its temperature decreases. In the summer, evaporation increases and contribution from shallow ground water stops. This lowers the fluid levels, allowing the temperature and concentration to increase. Possibly, pure shallow ground water contributes to the hot springs at times. The precise mechanism and relation between all the hydrologic, chemical and climate parameters are not presently known. Better definition and understanding of these relationships may provide more insight into the mechanism of the hot springs and its relationship to the geothermal reservoir.

In the most likely mechanism for the surface thermal manifestations shallow ground water flows from the small alluvial valleys west of the hot springs, and percolates deep enough to be heated and boiled by the hot ground and steam. The steam from the reservoir and ground water then ascends through fractures to the surface, condensing and accumulating on the impermeable clay layer several feet below the surface.

2.5.1.5 Hydrologic Balance

The hydrologic balance is a tally of all water entering and leaving a specified drainage area. The amount of water entering must equal the amount leaving to maintain water resources. If more water enters than leaves, then water in storage is increased. If more water leaves than enters, then water in storage is reduced. Calculation of the hydrologic balance will allow estimation of the practical sustained yield; that is, the amount of water that may be withdrawn from the system without producing undesirable effects. The practical sustained annual yield may exceed the mean annual recharge, particularly in arid regions where there may be large volumes of ground water in storage.

In the CGSA, there has been so little water use, and so few wells have been drilled that, at best, the parameters necessary for a hydrologic balance must be rough estimates. These estimates would be based largely on a conceptual model of the general ground water situation in the area, empirical relationships and analogy from other areas and a few points of factual control. As more wells are drilled and more data become available, these estimates can be refined to reflect the added control.

The hydrologic balance for Rose Valley shows total recharge approximately equalling total discharge at about 60,000 AF/YR. That portion which pertains to the ground water regime is summarized on Table 2.5.1-4. Derivation of the individual estimates is presented in Section 4 of the Hydrology Technical Report.

Table 2.5.1-4
SUMMARY OF ESTIMATED GROUND WATER BALANCE FOR ROSE VALLEY

Recharge	Estimated Annual Quantity (acre-feet/year, rounded)
Underflow from Haiwee Reservoir	600
Underflow from alluvial fans west of Haiwee Reservoir	Contribution not Presently Known
From precipitation on Sierra	1900-3000
From precipitation on Coso Range	0
From precipitation on valley floor	0
Imported water	100
Irrigation	900
	3500-4600
Discharge	
Irrigation withdrawal	3100
Little Lake surface evaporation	830
Evapotranspiration, other vegetated areas around Little Lake	40
Underflow to Indian Wells Valley	200-500
Domestic and stock withdrawal	30
Springs	30-190
	4100-4700

Within the roughness of the estimates the Rose Valley ground water basin presently appears to be near hydrologic equilibrium with a ground water recharge of 3500 to 4600 AF/yr and a discharge of 4100 to 4700 AF/yr. Ground water excess or deficiency is not more than several hundred acre-feet per year. This balance may be modified by further studies which would confirm the assumptions these estimates are based on, including:

A. Precipitation on the east slope of the Sierra

B. Precipitation/potential ground water recharge relation

C. Recharge from areas to the north, including underflow through the gorge south of Haiwee Reservoir and possibly through the alluvial fans to the west of the reservoir.

These assumptions are detailed in Sections 4.1 and 4.2 of the Hydrology Technical Report.

Ground water in storage for Rose Valley has been estimated by assuming an average specific yield for the saturated thickness of alluvial material in the valley. Assuming an unconfined aquifer with a 10 to 15 percent specific yield, the total volume of water in storage is 3.3 to 5 million acre-feet. Of this total, 1.4 to 2.2 million acre-feet is within 1000 feet of the surface. Most of the water in storage is believed to be usable but the geothermal reservoir fluid may extend into the alluvial material on the east side of the valley or saline water may occur in other locations.

2.5.1.6 Water Availability and Use

No surface water is available for consumptive use in or near the CGSA. Water is potentially available from several ground water basins. Areas that contain porous materials with water-bearing properties may be considered for ground water extraction. These include the alluvial sediments in Rose Valley, Upper Cactus Flat, McCloud Flat, Upper Coso Basin and Lower Coso Basin (Figure 2.5.1-1). Use of water extracted from the geothermal reservoir is considered in the design of the power plant system for cooling and the 323 acre-feet/year requirement per 50 MW (Section 1.3.5.4) is in excess of that use.

Rose Valley has been emphasized as a prime potential source of cooling water due to its size and potential ground water yield, its status as BLM administered land and its proximity to the primary area of projected development. Compared with Rose Valley, the other drainage basins are quite small, have lower rainfall, and have much less or no data available. Use of ground water from these other basins would require further assessment of ground water resources, most likely including drilling of several observation wells.

Water Use

Current water use is quite limited in Rose Valley and nil in Coso Basin. Rose Valley Ranch is the major water user, pumping about 3130 AF/yr (Hennis, 1979, personal communication). Domestic use is small due to the low population. Water use in Rose Valley is summarized in Table 2.5.1-5.

Table 2.5.1-5

ESTIMATED WATER USE IN ROSE VALLEY

Use and Location	Estimated Annual Quantity (acre-feet/year)
Irrigation	
Rose Valley Ranch	3130
Cal-Trans Rest Stop	14
Domestic & Stock	
Permanent Residents	7
Cal-Trans Rest Stop	14
Stock Watering	3
Transient Residents at Little Lake Hotel	5
Total	3200 (rounded)

2.5.2 Impacts of the Proposed Action on Hydrology

Geothermal development requires cooling water, which could displace other uses or degrade other supplies. It also produces enormous amounts of liquid waste which must disposed of. In the CGSA another hydrologic issue of particular importance is possible alteration of the Coso Hot Springs.

2.5.2.1 Background

Hydrologic impacts are best described by dividing geothermal development in the CGSA into two phases. The first is the preliminary exploration, exploratory well drilling, and construction of the development facilities. These would involve mostly short-term local hydrologic effects, which would consist mainly of impacts from surface erosion and drilling waste disposal.

This could possibly cause alteration of surface runoff and erosion patterns, sediment yield, and ground water degradation.

The second phase is geothermal field development and resources utilization activities. This would involve higher levels of runoff and more long-term regional effects. The impacts would result from geothermal reservoir utilization and injection and ground water withdrawal. The potential impacts may include:

1. Lowering of the water table in Rose Valley;

2. Degradation of natural water;

3. Alteration of surface thermal manifestations, including flow to Coso Hot Springs;

4. Localized cooling, mineral precipitation and/or depletion of the geothermal reservoir.

Precise quantification of these long-term impacts requires geothermal and ground water reservoir development data. Such data are not presently available. Hence, the analysis of the hydrologic impacts is semi-quantitative. It is based on analysis, interpretation and extrapolation of the limited available data. The assumptions, techniques and derivations of numeric estimates are detailed in the Hydrology Technical Report and those most pertinent to the following discussions are summarized.

Preliminary Exploration, Exploratory Well Drilling and Construction Activities

Insignificant impacts from alterations in runoff patterns and increases in erosion would occur from the preliminary exploration. Drilling wastes and test fluids could be produced in fairly large quantities during exploratory well drilling. If toxic, these may have to be trucked to a disposal site for Class I wastes. If not, they may be evaporated and buried in place, if the impacts of which would be low.

Increased runoff could occur on disturbed soils. Water erosion potential from drill pads in this stage ranges from slight to high depending upon which soil type the pads are located. Disturbance from drill pads located on highly erosive soils could greatly increase sediment yield and thus create active erosion in drainage channels, see Section 2.6. An approximate total of disturbance of 450 acres could occur in this stage if, as has been calculated, 100 wells are drilled in Zones 1 and 2, and 300 exploratory wells are drilled in Zones 3 and 4.

Geothermal Field Development, Resource Utilization

Well testing in the field development stage would also result in large quantities of waste and test fluids which could be disposed of by buring. In addition, spent geothermal fluids from resource utilization would be produced. As most of these fluids could be reinjected in available wells, impacts would be slight.

As in exploratory well drilling, sediment yield and erosion potential from disturbed sites created during field development would vary with the erosion susceptibility of the soil see Table 2.6.1-2.

Because approximately 800-1000 acres would be disturbed, increased runoff and subsequent erosion could be about double that of the exploratory stages. During periods of heavy rainfall, erosion on disturbed soils could displace large amounts of soils which would cause heavy cutting of downstream channels, and deposition of sediment in the playas. In 100 year storms, sediment could be deposited into Little Lake, and even farther.

2.5.2.2 Lowering the Water Table in Rose Valley

Water Use and Availability-- No surface water is available for use in the CGSA. Rose Valley is presently considered the most logical source for geothermal plant cooling water.

Potential combined water use by geothermal and present users may exceed natural recharge. Current and projected water use in Rose Valley is summarized in Tables 2.5.1-5, and 2.5.2-1. Ground water recharge and discharge is summarized in Table 2.5.1-4. Although it is extremely conjectural, if geothermal power production in the CGSA is extrapolated to a total of 550 MW by 2030, geothermal development water requirements would total about 4,300 AF/yr. Details of derivation of these estimates are presented in Sections 5.2 and 5.3 of the Hydrology Technical Report.

Table 2.5.2-1
PROJECTED WATER USE IN ROSE VALLEY

Use and Location		Estimated Annual Quantity (acre-feet/year, rounded) 1986a	1995
Irrigation			
Rose Valley Ranch	3130[b]		
Lewis Ranch/Coso Junction	1000		
Cal-Trans Rest Stop	14		
Total Irrigation		4100	4100
Domestic and Stock			
Permanent Residents	260		
Other	40		
Total		300	400
Industrial			
Geothermal Power Plant	390		
Geothermal well drilling (assumes 13 wells/year)	210		
Total Industrial		600	1800[c]
Total Use		5000	6500

a Or at completion of first 60 MWe of geothermal generating capacity.
b Irrigation application at Rose Valley Ranch could possibly increase by as much as 4600 AF/yr (See Hydrology Technical Report).
c Assuming 250 MW geothermal development.
Also, about 30 percent of irrigation application is estimated to recharge the ground water table (see Table 2.5.1.5).

The range in the recharge and discharge estimates and the assumptions used in deriving them make it difficult to determine at what point increased water demand in Rose Valley may overdraft the ground water reservoir. In the worst case it is presently overdrafted by about one thousand AF/yr. In the best case recharge presently exceeds discharge by about 500 AF/yr.

Total ground water in storage in Rose Valley is estimated at about 3.3 to 5 million acre-feet. Approximately 1.1 to 2.2 million acre-feet is within 1000 feet of the surface. Most is believed to be usable. The estimates are based on the volume of alluvial sediments in Rose Valley and their average assumed specific yield. The volume of sediments is based on a gravity survey that has some demonstrated inconsistencies. The identified inconsistencies were corrected, but the reliability of the interpretation remains somewhat dubious. Resurvey and reinterpretation of the gravity data would most probably reduce the ground water in storage estimates. The total ground water in storage estimate would be affected much more than the water availability in the upper one thousand feet. These assumptions and derivations are detailed in Section 4.3 and 3.1.2 of the Hydrology Technical Report.

If the water required for geothermal development tilts the hydrologic balance, as a first approximation, an average of 2100 to 3200 acre-feet of ground water in storage will be available per foot of drawdown from the upper one thousand feet of the ground water reservoir in Rose Valley. Naturally the water table will not be lowered evenly throughout the valley. Lowering will be greatest near pumping wells. Formations with adequate transmissivity to supply this water exist in Rose Valley.

Potential Impacts-- Estimated potential average annual water table lowering is summarized for the years 1979, 1986, and 1995 in Table 2.5.2-2. It is divided into two parts; one part assumes the "best case" situation and the other assumes a "worst case" condition. The "best case" is based on maximum recharge and minimum natural discharge from Table 2.5.1-4 and the water yield that would minimize drawdown. The "worst case" is based on minimum recharge, maximum natural discharge and minimum water yield per foot of drawdown. If it is assumed that total field development, from initial startup to final shut-down will take about 70 years, and average water use is at the 250 MW level, then the water table may be lowered a total of about 60 to 150 feet.

Lowering the water table in Rose Valley may:

A. —Reduce the quantity of ground water in storage

B. —Reduce the quantity of underflow into Indian Wells Valley

C. —Lower the water level in Little Lake

D. —Affect surface vegetation

E. —Degrade natural water

Table 2.5.2-2. ESTIMATED POTENTIAL AVERAGE ANNUAL WATER TABLE LOWERING IN ROSE VALLEY*

	BEST CASE					WORST CASE				
Year	Estimated Recharge (AF/yr)	Estimated Natural Discharge (AF/yr)	Estimated Water Use (AF/yr)	Change in Water Supply (AF/yr)	Estimated Water Table Change (ft/yr)	Estimated Recharge (AF/yr)	Estimated Natural Discharge (AF/yr)	Estimated Water Use (AF/yr)	Change in Water Supply (AF/yr)	Estimated Water Table Change (ft/yr)
1979	4600	900	3200	+ 500	+0.2	3500	1600	3200	-1300	-0.6
1986	4600	900	5000	-1300	-0.4	3500	1600	5000	-3100	-1.5
1995	4600	900	6600	-2900	-0.9	3500	1600	6600	-4700	-2.2

*Recharge, discharge and water use rounded to nearest one hundred acre-feet; water table change rounded to nearest 0.1 foot.

The first impact would decrease the amount of water available for future uses from this source. The second impact would result from a reduction in the hydraulic gradient between Rose Valley and Indian Wells Valley. Presently ground water recharge to Indian Wells Valley is estimated at 10,000 to 15,000 acre-feet/year (Bloyd, 1979). The quantity of underflow from Rose Valley, perhaps several hundred AF/YR, woulld represent a few percent of the total ground water recharge to Indian Wells Valley. This is discussed further in Section 4.2.3 of the Hydrology Technical Report. The third impact would occur since Little Lake is fed by ground water from natural springs. The degree of water level lowering in Little Lake is difficult to quantify for several reasons. First, the flow rates of the springs feeding in the Lake have not been measured. Second, the source and mechanism of these springs has not been identified. Third, the natural variation in the level of the Lake, has never been systematically recorded and fourth, the Lake level has historically been artificially maintained by ground water pumping. The fourth impact would affect only natural phreatophytic vegetation which is virtually nonexistent in Rose Valley, except for a small area immediatly adjacent to Little Lake. This effect is discussed in Section 2.8, Flora. The fifth potential impact is discussed in the following subsection.

2.5.2.3 Degradation of Natural Water

Geothermal fluid may be released at the surface via accidental spills, blowouts or leakage from surface facilities. Geothermal fluid may be re leased beneath the surface via well failure or unforeseen structural or stratagraphic pathways. Ground and/or surface water may be degraded by escape of noxious drilling muds from the well, sump or from leaching of drilling mud residues. Septic systems, if not properly designed and installed, may degrade ground or surface waters.

Insufficient data is available to define the present character of water throughout the Rose Valley, the possible locations of water withdrawal, or the details of hydraulic gradients. This also applies to the geothermal reservoir. Hence, location, distribution and quantity of presently nonusable water (nonusable water refers to water of quality too poor to suit its intended use; this generally is water with high salt content, high boron, fluoride or trace metals) in Rose Valley may increase or decrease depending on:

A. The location and extent of nonusable water;

B. The hydraulic relationships between the geothermal reservoir and the ground water reservoir;

C. Geothermal production and injection design;

D. The cooler ground water extraction location in Rose Valley.

For example, under the following set of hypothetical conditions ground water may be induced to flow from Rose Valley towards the geothermal reservoir:

There is some hydraulic communication between the Rose Valley ground water reservoir and the geothermal reservoir, and

The water level in the geothermal reservoir is lowered below the level of the ground water reservoir in Rose Valley.

Although it is premature to define specifics, in general, chemical and thermal pollution of ground water aquifers during injection of waste can result from escape of geothermal fluids via the following mechanisms:

1. Improperly constructed or deteriorated injection well;
2. Improperly constructed, deteriorated or ineffectively abandoned wells nearby;
3. Escape of injected fluid from the receiving formation through structural or stratigraphic pathways;
4. Hydrofracturing of confining formations with high-pressure injection;
5. Accidential spills at the ground surface;
6. Percolation from storage ponds (enhanced by higher temperatures);
7. Percolation from discharge of mineralized fluids through leaks in surface conveyances which are part of the injection system;
8. Chemical migration through confining beds due to osmotic forces.

Escape of fluid by any of these mechanisms would result in mixing of non-geothermal water with geothermal fluid. This would in most cases, result in increased total dissolved solids and trace metal concentrations in the non-geothermal water. (Table 2.5.1-3 has representative analyses of several types of water in the CGSA). In the vicinity of the prospective geothermal development there are many shallow (less than 100 ft. deep) abandoned wells at Coso Hot Springs, and the Devil's Kitchen, Nicol and Wheeler prospects. There are also about 20 heat flow holes drilled in 1975-1976 to maximum depths of about 300 feet in and around the CGSA. None of these wells intercepted usable water, hence this mechanism is unlikely.

Fluid escape along faults, at the surface or by osmotic forces are not anticipated to affect ground water quality in the reservoir development area in the Coso Range itself since there is no known perennial, usable ground water above the reservoir. Fluid flow into or out of the reservoir from Rose Valley or Coso Basin would depend on the existence of a conductive fault and the natural and induced hydraulic relations.

Accidental spills at the surface, percolation from holding ponds, blowouts (see Section 1.3.5.2) or leakage from surface conveyances would each entail similar pathways. The fluids would percolate from the surface downward into the nearer surface aquifers. A spill, if not contained, may also discharge fluids directly into the nearer surface aquifers. Such occurrences would be treated immediately. Pollution due to osmotic migration of chemical constituents is generally anticipated to be minor and insignificant.

Although escape of fluids by any of these mechanisms is of concern, the greatest risk of fluid escape is through the injection well itself (Talbot, 1972). Currently prescribed well construction practices and the large vertical distances between the injection zones and usable aquifers, reduce the probability of contamination of usable aquifers. The nearest used aquifer is in Rose Valley. Alluvial valleys adjacent to the reservoir may be potentially usable. It is not anticipated that any of these used or potential ground water sources would be directly affected by injection in the geothermal reservoir.

Septic Systems-- Assuming local health ordinances are followed, septic systems from potential residential development in Rose Valley are not anticipated to have any adverse impact.

2.5.2.4 Alteration of Surface Thermal Manifestations, Including Flow To Coso Hot Springs National Historic Site

Flow to the hot springs may increase or decrease due to geothermal production depending on reservoir development design and the precise nature of the hydraulic connection between the geothermal reservoir and the hot springs. Lowering of the water table and altering natural flow in the geothermal reservoir may affect the amount of steam condensate reaching the hot springs. This effect cannot be quantified at this time. However, it is anticipated that the effects of geothermal development will be less than if the hot springs were fed directly and solely by geothermal reservoir fluid for two reasons:

A. Steam is much less viscous and dense than water. It will rise above the water table and flow more pervasively than water.

B. Shallow ground water contributes to the hot springs. This contribution of shallow ground water will not be affected by geothermal development.

Construction activities may increase runoff potential upstream from the hot springs. This surface disturbance may produce a minor increase in shallow ground water contribution to the hot springs. The cultural and socio-economic aspects of alteration of flow to the hot springs are discussed in Sections 2.10.2 and 2.12.2.

2.5.2.5 Localized Cooling, Mineral Precipitation and/or Depletion of the Geothermal Reservoir

Injection of spent fluids may cause localized cooling in the geothermal reservoir. Production and injection may cause mineral precipitation (plugging) around wells, thereby reducing productivity and/or injectivity, respectively. The extent or recharge mechanism of the resource is not presently known. Environmental effects of depletion of the resource would depend on the hydraulic relations between the geothermal and other ground water systems.

2.6 SOILS

2.6.1 Present Soils Setting

Twenty-one predominant soils occur in the CGSA. They have been grouped into ten General Soil Map Units (Plate 2.6-1) based upon similar soil and landform characteristics. Table 2.6.1-1 shows how soils are grouped on Plate 2.6-1. Table 2.6.1-2 gives selected properties and qualities of the 21 soils. The soils on granitic uplands and steep sideslopes of rhyolite domes of Map Units 6 and 8 generally have a moderate to high susceptibility to water erosion. Map Units 1, 4, 5, and 7 have a slight to moderate susceptibility to water erosion. Soils of the valley bottoms and playa areas in Map Unit 2 are slightly susceptible to water erosion. The hazard of wind erosion is high on Map Units 1, 2, 3, 4, 6, and 7.

The total of all map units rated as highly susceptible to wind or water covers the bulk of the CGSA. Generally, soils on the more level areas are susceptible to wind erosion, and the soils on the hillsides are susceptible to water erosion. Soils on basaltic uplands, lava flows, cinder cones and deposits, and rhyolite domes are less susceptible to erosion,

Table 2.6-1-1*

Component Soils or Landforms of General Soil Map Units

Map Symbol	Soil or Landform
1	Dunmovin, Arizo, Garlock
2	Dunmovin, Lavic, Wasco Variant, River Wash
3	Alko Variant, Joshua Variant, Nebona Variant, Hooten Variant, Arizo
4	Alko Variant, Dunmovin Variant, Nebona Variant
5	Gass Variant, Garlock Variant, Sparkhule
6	Maynard Lake, Stumble, Haybourne
7	Maynard Lake, Stumble
8	Coso, Rock Outcrop, Haiwee, Shoken, Coso Variant, Haiwee Variant
9	Rubble Land, Torriorthents, Rock Outcrop
10	Cinder Land, Lava Flows

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* Refer to Section 5.0 of the CGSA Technical Report for a more detailed discussion of the General Soil Map Units.

TABLE 2.6-1-2

RATINGS FOR SELECTED SOILS
PROPERTIES AND QUALITIES

Soil Name	Class				Limiting Layer		Precipitation Annual	Erosion Susceptibility	Area Acres	Percent of Soil Series
	Depth Inches	Permeability	Runoff	Drainage	Kind	Thickness Inches				
Alko Variant	8-20	<.06	Medium to Rapid	Well Drained	Hardpan	Not Known	5-6	Moderate to High	2,123	2.8
Arizo	20.0	20.0	Very Slow	Excessive	None	None	5-6	Slight (Water) High (Wind)	695	0.9
Coso	8-20 to Weathered Granite	2.0-6.0	Medium to Rapid	Somewhat Excessive	Weathered Bedrock	--	6-7	High	6,548	8.7
Coso Variant	20-60 to Weathered Granite	0.6-2.0	Medium	Well Drained	Weathered Bedrock	--	6-7	Moderate	1,118	1.5
Dunmovin	More Than 60	6.0-20	Very Slow to Slow	Somewhat Excessive	None	None	5-6	Slight (Water) High (Wind)	15,970	21.3
Dunmovin Variant	>60	0.2-0.6	Slow to Medium	Somewhat Excessive	Weakly Cemented Substra-tum	14	5-6	Slight (Water) High (Wind)	1,643	2.2
Garlock	>60	0.2-0.6	Medium	Well Drained	None	None	5-6	Moderate	96	0.1

TABLE 2.6-1-2 (Cont.)

RATINGS FOR SELECTED SOILS

PROPERTIES AND QUALITIES

Soil Name	Class				Limiting Layer		Precipitation Annual	Erosion Susceptibility	Area Acres	Percent of Soil Series
	Depth Inches	Permeability	Runoff	Drainage	Kind	Thickness Inches				
Joshua Variant	>60	0.6-2.0	Slow	Well Drained	None	None	5-6	Slight (Water) Moderate (Wind)	1,328	1.8
Lavic	>60	0.6-2.0	Very Slow	Well Drained	None	None	5-6	Slight (Water) High (Wind)	2,670	3.6
Maynard Lake	>60	6.0-20	Medium	Somewhat Excessive	None	None	5-6	Moderate (Water) High (Wind)	8,208	10.9
Nebona Variant	8-15	<.06	Slow to Rapid	Well Drained	Hardpan	Not Known	5-6	Slight to Moderate	2,191	2.9
Shoken	3-15 to Granite	6.0-20	Medium to Rapid	Somewhat Excessive	Weathered Bedrock	--	7-8	Moderate to High (Water) Moderate (Wind)	1,686	2.2
Sparkhule	14-20 to Basalt	0.2-0.6	Medium	Well Drained	14-20 to Bedrock	6-14	5-6	Moderate	780	1.0
Stumble	>60	6.0-20	Medium	Somewhat Excessive	None	None	7-8	Moderate (Water) High (Wind)	4,166	5.5
Wasco Variant	>60	0.2-0.6	Very Slow	Well Drained	Weakly Cemented Substra-tum	36	5-6	Slight (Water) Moderate (Wind)	1,016	1.4

TABLE 2.6-1-2 (Cont.)

RATINGS FOR SELECTED SOILS

PROPERTIES AND QUALITIES

Soil Name	Class				Limiting Layer		Precipitation Annual	Erosion Susceptibility	Area Acres	Percent of Soil Series
	Depth Inches	Permeability	Runoff	Drainage	Kind	Thickness Inches				
Garlock Variant	26-40 Over Basalt And Cinders	0.2-0.6	Slow to Medium	Well Drained	26-40" to Basalt And Cinders	--	5-6	Slight to Moderate (Water) High (Wind)	1,614	2.1
Gass Variant	20-40 to Basalt And Cinders	0.06-0.2	Slow to Medium	Well Drained	Bedrock	--	5-6	Slight to Moderate	873	1.2
Haiwee	8-20 to Granite	2.0-6.0	Medium to Rapid	Somewhat Excessive	Bedrock	--	6-7	High	2,134	2.8
Haiwee Variant	10-20 to Andesite	0.6-2.0	Medium to Rapid	Somewhat Excessive	Bedrock	--	7-8	High	308	0.4
Haybourne	>60	2.0-6.0	Slow to Medium	Well Drained	None	None	7-8	Slight to Moderate (Water) High (Wind)	941	1.3
Hooten Variant	8-20 to Hardpan	<.06	Slow to Medium	Well Drained	Hardpan	4	5-6	Slight to Moderate (Water) High (Wind)	450	0.6

2.6.2 Impacts of the Proposed Action on Soils

Based upon input from other resources and Chapter 1, Proposed Action , environmental impacts to soil resources resulting from possible implementation of the Proposed Action will be presented and analyzed using data and interpretations derived from the Soils Technical Report.

2.6.2.1 Sensitivity and Limitations of Soils

The soils of the CGSA are quite variable and pose many different kinds of sensitivities and limitations to development. Sensitivities, capabilities, and constraints imposed by soils to various land uses are summarized in tabular form by soil map unit in an appendix to the Soil Technical Report.

Sensitivities and constraints of the soils include the following:

1. Soils of the playa bottoms are subject to soil compaction when wet.
2. The Maynard Lake and Stumble soils developed in cinder and ashfall deposits are highly susceptible to wind and water erosion on slopes greater than 30 percent.
3. Garlock and Garlock Variant soils mapped on old terraces and basalt flows have high soil shrink-swell potential and are less desirable building sites.
4. Coso and Haiwee soils developed on granitic rock occur on steep, rocky slopes and pose difficult conditions for road construction.
5. Alko, Nebona, and Nebona Variant soils are bouldery and shallow to hardpan, and pose difficult road construction conditions. Once disturbed, these areas would be difficult to revegetate.
6. Areas mapped as Arizo soils and Riverwash may be subject to periodic flash flooding.
7. An area of landslides and rockfall was mapped north of Coso Hot Springs and may be reactivated if disturbed.

Sensitive areas have been delineated on Plate 2.6-2, Soils Sensitivities.

2.6.2.2 Preliminary Exploration

The initial exploratory program will consist predominantly of field geophysical investigations which may require Surface vehicular access to most areas of the CGSA. Off-road travel will be regulated within the Naval Weapons Center (NWC) and on public lands. Impacts to soil resources from off-road vehicular travel include displacement of soils in tire ruts and wheel holes and soil compaction. The degree of localized damage to the soil is a function of soil properties. Tire ruts on slopes can divert surface runoff, and may cause accelerated soil erosion which may persist for long periods of time after soil disturbance. The sandy Maynard Lake and Stumble soils on slopes greater than 30 percent present the most serious potential soil erosion impacts.

Soil compaction may occur when the soil surface is wet/moist. The finer textured soils of the the playas and adjacent areas are the most susceptible to soil compaction. A secondary impact caused by soil compaction is the impedance to revegetation.

A third impact may result from drill cuttings left on the soil surface. This is estimated to be from 0.8 to 1.6 cubic meters of drill cuttings per shallow temperature gradient hole (USFW, 1976). Since cuttings are usually low in fertility and do not support vegetation, they would leave local visual scars. There would also be minor impacts from spills of gasoline and lubricating materials, litter from the crew, parking of personal vehicles, and other associated activities. Impacts from preliminary exploration are considered minor.

2.6.2.3 Exploratory Well Drilling

Estimated acreages of surface disturbance due to exploratory well drilling activities are outlined in Table 1.3-2 of Chapter 1 which shows totals of estimated acreages to be disturbed per 50 MW generation station. An estimated 112.5 acres of land would be disturbed in Zones 1 and 2 by exploratory well drilling. Soils are predominantly the sandy Maynard Lake and Stumble series.

During drilling operations, there is a slight potential for well blowout. The probability of occurrence can be minimized by proper design, installation, supervision, and adherence to the USGS GRO Orders. Mud sumps and reserve pits could also breach or overflow.

Should a blowout occur, impacts include the spreading of sand, gravel, and rock fragments on the soil surface around the drilling platform. If unabated, the soil around the drill hole may erode inward, enlarging the hole to form a crater, into which the drilling rig itself may collapse (Cook and Raschen, 1976). The amount of land disturbed would be related to the nature and duration of a blowout. Geothermal fluids and possibly toxic materials (including drilling mud) may also be released on the surrounding soil surface from blowouts or sump overflows. This could contaminate the soil with dissolved salts. The most probable impact of a release of geothermal fluid under pressure would be erosion and alkalinization of the area affected due to the anticipated high concentration of sodium in the fluid. In addition, boron is expected to be present in high concentration in the geothermal fluid (Appendix B, Geothermal Development Model). Additions of sodium and boron to the soil would restrict plant growth. Boron is generally considered toxic to plants in solution concentrations exceeding 2-3 ppm. The exact nature of the drilling mud and geothermal fluid is unknown.

Existing topsoil would be disturbed in this and subsequent stages of development. Surface disturbances would cause associated losses of soil productivity, expected to occur throughout the life of the project. This loss is considered to be insignificant when viewed within a regional context; however, the loss may be apparent for many years after the project life, as soils in a desert environment do not quickly revegetate. Soil areas most sensitive to disturbance consist of the drier south and southwest facing slopes.

Loss of wildlife habitat, rangeland uses, and agricultural productivity would be secondary impacts related to surface disturbance of soils (refer to Section 2.7, Wildlife, and Section 2.11, Land Uses). Rangeland and agricultural productivity would be minor.

Soil slumping and rock slides may occur in areas of steep slopes due to construction activities. Landslides have been mapped near Sec. 33, T.21S, R.39E, and could possibly be reactivated due to road and drill pad construction. Rockslides may occur on steeply sloping rocky soils and landforms. Map Units 130, 131, and 160 contain 15 to 35 percent rock outcrops or rubble (see Plate 2, Soil Technical Report). Rockslides constitute a safety hazard to construction workers and equipment. Soils occurring extensively in Zones 1 and 2 having engineering limitations for geothermal facilities include the Dunmovin, Maynard Lake, and Stumble soils (Map Units 1, 6, 7, Plate 2.6-2, Soils Sensitivities). These non-cohesive sandy soils have a low bearing strength and a nearly uniform particle size distribution, which renders them poorly suited for mud sump and reserve pit construction. Refer to the Appendix--Soil Technical Report for a detailed assessment of engineering properties, uses, and limitations of soils.

An identified impact due to surface disturbances includes increases in runoff and erosion caused by improved roads and facilities. Water erosion due to runoff channelization of access roads, drill pads, cuts and fills, and mud sumps and reserve pit sidewalls is a potential direct soil impact. This impact would be confined to localized areas of surface disturbance, and may potentially occur throughout the life of the project. As discussed in 2.5.2 the significance depends upon soil vunerability.

2.6.2.4 Field Development

The impacts to soil resources due to field development, are expected to be similar to those associated with exploratory well drilling. The magnitude of the field development operations is generally much larger, and the degree of impacts to soils is correspondingly greater. Some 800 to 1,000 acres of land may be disturbed in this stage. This must be viewed as a significant impact on soil resources.

In addition to well drilling activities, power generation facilities and transmission lines are to be constructed during this stage of development. Impacts associated with these losses of soil productivity are expected to be similar to those described for exploratory well drilling.

The most probable transmission line corridor (shown on Map 1.3-3) will cross approximately seven miles of soils Map Unit 180, consisting predominantly of Nebona Variant and Alko Variant soils (see Plate 2.6-2, Soils Sensitivities).

These soils may pose constraints to corridor construction, as they are underlain by a silica cemented hardpan at depths ranging from 8 to 20 inches. Cuts by road building equipment through areas of these soils may create rubble poorly suited for fill material. This rubble may potentially be dumped on the the landscape, and constitute a visual impact. Water erosion of this corridor is a potential insignificant impact occurring throughout the life of the project. Revegetation of soils underlain by hardpan will be particularly difficult.

2.6.2.5 Resource Utilization

Impacts to soils during this stage of development are perceived to be similar to those described above, on a magnitude consistent with the amount of ongoing development.

2.6.2.6 Close-out

This phase includes abandonment of wells, removal of generating facilities, and restoration of the area following requirements of USGS.

Additional disturbance will occur as building pads are regraded and topsoiled.

Wind and water erosion may occur on replaced topsoil prior to its stabilization. This potentially constitutes a significant direct impact, since these occurrences may deplete the total amount of topsoil resources available for revegetation. Because disturbed soils recover slowly in an arid environment, the potential impacts are considered long-term.

2.7 WILDLIFE

The desert ecosystem of the CGSA and vicinity supports a relatively abundant fauna. Though there is not a great diversity of species resident, many migratory bird species visit the area. In the following discussion, wildlife are grouped into major categories corresponding to the field surveys performed for this study.

2.7.1 Present Wildlife Setting

The following discussion is based upon data, including species lists, which has been compiled and placed in the Flora and Wildlife Technical Reports.

2.7.1.1 Aquatic Wildlife and Habitats

Three aquatic habitat types exist, all outside the CGSA boundaries but in the immediate vicinity, and all important for at least some of the wildlife species resident within the CGSA: Little Lake, Haiwee Spring, and several small streams that flow down the eastern scarp of the Sierras, their waters usually dissipating before entering Rose Valley.

Little Lake is a small, shallow body of water approximately one mile in length which occupies a Pleistocene river channel bounded on each side by lava flows. The lake is probably of recent origin; however, a shallow lake-marsh may have existed here prior to construction of an earth earth dike which dams the lake at its southern end and along what is now U.S. Highway 395. Since maximum depth is only five feet, wind action causes extensive mixing of its waters. Biologically the lake is very productive, its brown-green color indicating a dense population of microscopic organisms (plankton). Two species of introduced fish are abundant: the mosquito fish (Gambusia affinis) and the Sacramento perch (Archoplites interruptus). Other aquatic species include damselflies, mayflies and other insects. The water level in this hot dry area is dependent upon a constant ground water source to supply the three springs along the western shore line which feed slightly alkaline water into the lake. At times of drought water is pumped from wells located at the north end of the lake, maintaining sufficient levels to attract waterfowl for hunting.

Haiwee Spring consists of a series of pools with some connecting streams exhibiting flowing water during winter and spring. The diversity of aquatic species present indicates that some water is present throughout the year. Arroyo willows (Salix laevigata) line the stream. Aquatic invertebrates are numerous, and several aquatic plants are also present. Haiwee Spring water is derived from runoff and subsurface waters in the Coso Range north and east of the CGSA; it would therefore probably not be affected by drawdown to the south or west.

Several small streams flow down out of the Sierras and percolate into the gravel alluvium in Rose Valley at about 4,000 feet elevation. These streams contain low to moderate mineral content and a good population of aquatic invertebrates (insects, e.g.). Water from these streams does not reach the CGSA except during heavy rains.

No rare or endangered species of the aquatic plants or animals were found in any of these three aquatic habitat types, nor were any uncommon or especially significant or unique species encountered.

2.7.1.2 Amphibian and Reptilian Wildlife and Habitats

The CGSA contains reptile and amphibian species from both the northern Mojave Desert and the southern Great Basin. A few small aquatic areas and considerable topographic variation provide a broad range of habitats for these species within the CGSA. A total of 4 species of frogs and toads, 14 species of lizards, 16 of snakes and 1 turtle (the desert tortoise, Gopherus agassizi) were found. The majority of species are typical of most of the Mojave Desert to the south and east; for example, the common side-blotched lizard (Uta stansburiana), the desert iguana (Dipsoraurus dorsalis), the desert spiny lizard (Sceloporus magister), and the desert night lizard (Xantusia vigilis). A few, such as the western toad (Bufo boreas), pacific treefrog (Hyla regilla), southern alligator lizard (Gerrhonotus multicarinatus) and the western rattlesnake (Crotalus viridis), are coastal or Sierran in origin. The bullfrog (Rana catesbiana) is native to the eastern states but has been widely introduced in the west and occurs in Little Lake. The remainder of the species are derived from the Great Basin Desert to the north; these include the Great Basin spadefoot toad (Scaphiopus intermontanus), and striped whipsnake (Masticophis taeniatus).

Two important amphibian and reptile habitats in the CGSA vicinity seem especially vulnerable to disturbance. Haiwee Spring contains a relict population of western toads, isolated in this small stream by miles of desert. While this species is a common habitant of desert springs, its distribution within desert areas is limited by the occurrence of suitable habitat. At present the spring receives considerable impact from both cattle and feral burros. If water levels drop, or exotic species such as the bullfrog are introduced from Little Lake, the western toad population could be eliminated at Haiwee Spring. The second sensitive habitat type comprises desert washes. During infrequent rains, water flows along these sandy courses and has produced rich communities of plants; washes are thus good habitat for reptiles and certain amphibians, and their preservation is important for these species. Washes are vulnerable to disturbance by vehicle use, since they often cut through otherwise impassable terrain and are frequently used as a means of access to remote areas.

The only uncommon species, of the 31 encountered, was the desert tortoise, which is fully protected by the State of California, though not included in Federal listings of threatened or endangered species. It occurs in the Mojave Desert as well as the deserts of Utah, Nevada, Arizona and Sonora; the CGSA is presumed to be near the northern limit of its range. One individual, found near the Coso Junction rest stop, may have been a vagrant or a released pet. It is doubtful that any breeding populations occur north of the Ridgecrest area.

2.7.1.3 Avian Wildlife and Habitats

The bird survey of the CGSA was divided into three parts: breeding birds, winter birds, and migratory species. Special attention was paid to raptor use of the area, and to the possible presence of any endangered, threatened, or rare species.

The breeding bird survey was conducted in eight specially selected areas during the spring of 1979. The study plots represent the various habitat types located within the CGSA; see also Section 2.8 and the Flora and Wildlife Technical Reports. The following numbers of species were found to be breeding in the eight plant communities selected; 4 species in the Creosotebush Scrub, 8 in the Joshua Tree Woodland, 4 in Shadscale Scrub, 5 in Desert Scrub, 6 at Haiwee Spring, 5 in the Creosotebush Scrub on Southern Sierra slopes, 5 at Coso Hot Springs, and 18 at Little Lake. The total number of permanent resident bird species found breeding in the area was 33. An additional 22 species breed in the area during migratory periods but are not year-round residents. Some common residents of the area are listed below by plant community.

The Shadscale, Desert, and Creosotebush Scrub habitats (corresponding to Shadscale Scrub, Mixed Desert Scrub and Creosotebush-Burroweed Scrub associations described in Section 2.8) include the following species: sage sparrow (Amphispiza belli), black-throated sparrow (A. bilineata), raven (Corvus corax), rock wren (Salpinctes obsoletus), and horned lark (Eremophila alpestris). The Joshua Tree Woodland community (see Figures 2.8.1-7) contains cactus wren (Campylorhynchus brunneicapillus), sage sparrow, Brewer's sparrow (Spizella breweri), black-throated sparrow and house finch (Carpodacus mexicanus). In the vegetated areas around Little Lake and Haiwee Spring, lesser goldfinch (Spinus psaltria) and house finch were common. Also common at Little Lake are numerous waterfowl species, including the pied-billed grebe (Podilymbus podiceps) and mallard (Anas platyrhynchos).

Migratory birds were also studied in the eight study plots during winter 1978-79 and spring 1979. Sixty-eight migrant species were found on the CGSA. Many of these migrants (23 species) were water birds which nest in the northern states and Canada and winter at the Salton Sea and along the Gulf of California; these included the California gull (Larus californicus), eared grebe (Podiceps nigricollis) and Wilson's phalarope (Steganopus tricolor). As these may settle on any body of water along their migration route, Little Lake, Haiwee Spring and any desert playas that contain water are important habitats for them. Forty-five species of land-bird migrants were noted, including three species of migrant raptors: the short-eared owl (Asio flammeus), osprey (Pandion haliaetus), and Swainson's hawk (Buteo swainsoni). Most land birds migrate at night; settling at daybreak to feed and rest and seeking out trees and water. Desert oases tend to concentrate migrants, and such aggregations were observed in the study area, notably at Little Lake, Haiwee Spring, the Coso Junction rest stop and at Rose Valley Ranch. Raptor migrants (and all raptors) tend to be most numerous along the power lines in Rose Valley where the transmission towers give them roosting spots and the Shadscale Scrub habitat harbors prey (small mammals) for raptors.

Wintering avifauna in the CGSA vicinity (as distinct from the migrants stopping on their way south) can be divided into three groups: water birds, raptors, and other land birds. Water birds congregate at Little Lake, the only suitable habitat for them in the vicinity. Ducks, which are hunted on Little Lake from mid-October to the end of January, reach peak numbers on the lake just after the close of the hunting season, with a maximum of 1,000 sighted in one observation day. (Coot, which are not hunted, numbered up to 1,500 per observation day during the winter of 1978-79.) A number of other water birds spend some of the winter months at Little Lake; the common are American coot (Fulica americana), canvasback duck (Athya valisineria), pintail duck (Anas acuta), and ruddy duck (Oxyura jamaicensis). Several land birds winter in the CGSA vicinity. These small ground-dwelling birds appear to prefer weedy areas around the developed pastures south of Little Lake and at the Rose Valley Ranch. The most common species of bird wintering on the CGSA is the White Crowned sparrow (Zonotrichia leucophrys).

Raptors of the CGSA were also surveyed by Zembal et al. (1978), who made 150 sightings during the winter months of 1977-1978. The present study recorded 203 sightings during the period October 1978 - May 1979. In addition to the migrant raptors mentioned above, 13 other raptor species were observed, most of them in the Rose Valley area. Among the most numerous were the red-tailed hawk (Buteo jamaicensis), rough-legged hawk (B. lagopus),

golden eagle (Aquila chrysaetos), and long-eared owl (Asio otus). The prairie falcon (Falco mexicanus) was also sighted. In addition to power lines, a second area of significant use is the mountainous region between Volcano Peak and Sugarloaf Mountain.

The National Audubon Society publishes an annual Blue List of bird species that show decreasing population trends. It is meant to be an "early warning list" for troubled species whose decline may not always be otherwise apparent. The Blue List for 1979 includes 10 species found in the Coso area, mostly as migrants. Only two species, the prairie falcon and burrowing owl (Speotyto cunicularia), are residents of the CGSA. Another three species, canvasback duck, ferruginous hawk (Buteo regalis), and marsh hawk (Circus cyaneus), winter in the study area. No state or Federal rare, threatened or endangered species of birds were sighted during the study.

what scientific names?
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The only game bird species of significance are the introduced chukar partridge; mourning doves and the Gambel quail are also present.

Several areas within and near the CGSA can be considered sensitive habitats for avifauna. Little Lake and the pasture nearby are important stopping points for many water and land birds. Raptors frequently roost on the high cliffs east of the lake, and at least one pair of prairie falcons was observed nesting there. Other areas used by raptors include the 200 foot high rocky ridges bordering the Joshua Tree Woodland study plot (see Figure 2.7.2-1), the hills near Haiwee Spring, lava cliffs one mile south of Coso Hot Springs and other high points. Their favorite roosts are the power transmission lines running the length of Rose Valley. Of the arid areas, other than Rose Valley, the Joshua Tree Woodland habitat contained the greatest numbers and greatest variety of species. Birds were also sighted at Coso Hot Springs, but the area is disturbed by human use and burro concentrations, and plant cover is quite sparse.

2.7.1.4 Mammalian Wildlife and Habitat: Small Mammals and Carnivores

Study of the mammalian fauna in the CGSA was divided into four parts: bats, rodents, carnivores, and other larger mammals.

Fall and summer studies of bat populations were carried out at seven locations within and adjacent to the CGSA . The permanent bat fauna includes five species, all common and widely distributed throughout the California deserts: California myotis (*Myotis californicus*), small-footed myotis (*M. leibii*), western pipistrelle (*Pipistrellus hesperus*), Townsend's big-eared bat (*Plecotus townsendii*) and pallid bat (*Antrozous pallidus*). (Five other species, all common in western states, may also be present though they have not yet been collected in the CGSA. A sixth western species, the spotted bat (*Euderma maculatum*), was not sighted, though it may be expected to occur in the area. It is relatively rare, though not presently listed by the U.S. Fish and Wildlife Service or the California Fish and Game Commission.) Two additional species, long-legged myotis (*M. volans*) and silver- haired bat (*Lasionycteris noctivagans*), taken only in October of 1978, were apparently seasonal transients in the Coso area; both are common elsewhere in western states. The greatest capture success for bats was achieved at Haiwee Spring, where all seven species were collected. No large bat colonies were discovered. Bat populations in the CGSA are almost entirely dependent on natural rock crevices for their daytime roosts. Water sources are essential for them and hence should be considered sensitive areas for these mammals.

The rodent and lagomorph (rabbit and hare) fauna include 16 species. The desert cottontail (*Sylvilagus audubonii*), and black-tailed jackrabbit (*Lepus californicus*), are commonly observed in all habitat types. The California ground squirrel (*Spermophilus beecheyi*), and Botta's pocket gopher (*Thomomys bottae*), were recorded during this study for the first time in the CGSA. Live-trapping at 5 study sites yielded 2,292 individuals representing 10 species of nocturnal rodents. The trapping sites were similar in total numbers of rodents captured. Live-trapping for ground squirrels was performed at eight sites. Antelope ground squirrels (Ammospermophilus leucurus), were taken in good numbers at all sites. The Mohave ground squirrel (Spermophilus mohavensis), a species designated as rare by the California Department of Fish and Game, was found to be widely distributed through all habitats. A total of 124 individuals were live-captured at seven of the eight sampling areas in June and July 1979; at Cactus Peak, (Mixed Desert Scrub), none were taken.

Carnivore presence was determined by sightings and by means of more than 100 scent-posts (stakes covered with an attractant), each surrounded by a circle of fine, brushed clay powder in which tracks were easily identified. No estimates of the numbers, but only of the presence, of species is possible using this method. From observation, coyote (Canis latrans), appeared to be the most abundant carnivores in the region. Four other species were also found. Kit foxes (Vulpes macrotis), occur throughout the CGSA; the bobcat (Lynx rufus), undoubtedly uses all habitats in the study area, though it was only tracked at two stations; gray foxes (Urocyon cinereoargenteus), were recorded at one station near Haiwee Spring and are probably restricted to that riparian habitat and the rocky canyons near by; and the ringtail cat (Bassariscus astutus), (fully protected under California law) was documented at two stations in the hills on the east side of Rose Valley and are probably distributed throughout in cliffs and rocky hillsides. In addition, Zembal et al. (1978) reported the presence of the longtailed weasel (Mustela frenata), Badgers (Taxidea taxus), near Coso Hot Springs, and mountain lions (Felix concolor, in Joshua Tree Woodland on the northern edge of the CGSA.

Mammal habitats sensitive to disturbance include Haiwee Spring, a water source for bats and other mammals. Denning sites for carnivores are sensitive; denning for most species is likely to occur more frequently in the rocky and mountainous areas.

2.7.1.5 Larger Mammals and Habitats

The only large mammals on the CGSA other than domestic cattle (and aside from mountain lions) are feral burros. Counts of burros were made in the winter and spring months of 1979 by driving along permanent roads. A maximum of 52 burros were observed during the January census, mostly males and mainly in the vicinity of Coso Hot Springs and near the stock pond north of Cactus Peak. Burros apparently migrate out of the CGSA in winter, when water is more prevalent, and Coso Hot Springs and Haiwee Spring are less important. A maximum of 235 burros were observed during the May census, mainly at Coso Hot Springs and Haiwee Spring, with lesser use at the stock pond near Cactus Peak. This burro population is part of a larger herd which inhabits the NWC. The significance of Coso Hot Springs as a water source decreases in summer, since the cattle trough at the springs is turned off when cattle are removed in early May and only a trickle of water flows into the tank. However, burros continue to use the area heavily in summer, even queueing up to drink at the tank. Haiwee Spring, located some four miles to the north, is the only important permanent water source in the area in the summer months, and it becomes vital to the survival of many burros, as well as for other wildlife. The valley leading from Coso Hot Springs to Haiwee Spring is also heavily utilized in summer months. The burro population is presently trampling and overbrowsing the area around both these water sources. Most of the platable plant species are severely hedged or virtually absent.

2.7.1.6 Rare, Endangered, Threatened, and Protected Species

None of the species encountered, known or expected within the CGSA or immediate vicinity is on Federal listings of threatened or endangered species. One species (the Mohave ground squirrel) is listed as rare by the California Fish and Game Commission; this species was found to be relatively abundant, at the time of this study, in virtually all habitat types in the CGSA. The ringtail cat, a carnivore, and the desert tortoise (the state reptile), are fully protected under California law though not included in state or Federal listings of rare, threatened or endangered species. The ringtail probably utilizes all habitats within the CGSA. No estimate was made of its numbers in the area. No other rare or protected wildlife species are known within the study area, though several relatively uncommonly sighted raptors were observed.

2.7.2 Impacts of the Proposed Action on Wildlife

Impacts were estimated on the basis of field survey data, published material on geothermal impacts on wildlife, data from other surveys conducted for this ES (e.g., noise, soils) and information from Chapter 1.

2.7.2.1 Wildlife Sensitivity to Geothermal Development

Two aspects of geothermal development that would impact wildlife are habitat removal, and disturbance due to noise and human presence. Noise may be continuous (such as the rushing water sound of a cooling tower) or periodic (such as a car door slamming or the operation of a jackhammer). The effect of noise on wildlife is a new field of research and few conclusive data are available. However, recent studies give valuable insight into the probable impacts of noise on animals. Though most of these studies concern species which do not occur within the CGSA, they indicate possible responses of similar vertebrates that do occur in the study area.

Studies by Bondello and Brattstrom (1979a) indicate that motorcycle sounds may stimulate emergence behavior in burrowed Couch's spadefoot toads (Scaphiopus couchi). Toads apparently receive accoustic stimuli from motorcycle noise similar to those received during thunderstorms; they emerge to gather water, and instead encounter the danger of being crushed by vehicles (op. cit.). Dune buggy sounds were demonstrated to cause hearing loss in the Mojave fringe-toed lizard (Uma scoparis) making it unable to sense sound levels similar to those produced by potential predators (op. cit.). The same authors have demonstrated that the desert kangaroo rat (Dipodomys deserti) can also suffer hearing impairment due to recreational and other vehicular traffic sounds, rendering it more vulnerable to nocturnal predation by sidewinders (Crotalus cerastes). Auditory recovery from an exposure to 500 seconds of 95 dBA dune buggy sounds required 21 days.

Brattstrom and Bondello (1978) have also compiled an extensive bibliography (2568 citations) on the effects of noise on non- human vertabrates. Unfortunately, little research has been carried out on birds. The best studies on noise impacts to birds from geothermal development are currently being conducted at the Raft River Test Site in southern Idaho. Here nesting ferruginous hawks were found to be equally sensitive to both noise and human presence. Results indicate that both noise and human activity within one-half mile of the hawks may prevent normal nesting (White, D., 1979, personal communication).

The other impact which all wildlife would experience in varying degrees include habitat removal from land clearing and construction activities; for some species habitat loss is expected to present the most severe impact. Water drawdown (e.g., at Little Lake) could reduce or alter vegetative cover. Loss of surface water itself would be a potential impact in this desert area. Construction of fences or other barriers to wildlife movements may affect large mammals. These impacts are summarized by wildlife form below.

Birds. Birds are probably the vertebrates most sensitive to both noise and human presence. Geothermal development within the CGSA could alter roosting, feeding and reproductive patterns for birds in general. The most sensitive would be raptors (hawks and owls), which tend to avoid humans; their behavior would be modified by the presence of workmen and the operation of construction equipment, and the birds adapt to human intrusion

* Loud construction noise could startle both raptors and smaller birds. Once power generation begins, many of these species may move back into areas surrounding the plant if suitable habitat remains. For example, bluebirds have resumed nesting within 200 feet of a power plant at The Geysers, where noise levels are about 60 dBA (P. Leitner, 1979, personal communication).

Raptors would be negatively affected by disturbance of predator/prey relationships (such as could result from habitat destruction and reduction of rodent populations). Smaller birds would be directly affected by habitat removal, as they are dependent upon the vegetation in a smaller area. They can, of course, move to adjacent habitat if the destruction is not too widespread, and if the disturbance does not occur during their nesting activities. All bird species would be affected if reduction or loss of the few water sources should take place; waterfowl and migrants (both land and water species) would be especially affected.

Mammalian Carnivores. Carnivorous mammals are also sensitive to human presence and noise. These animals will avoid areas near construction and would be deprived of hunting on those portions of the CGSA which are subject to exploration and development activities. However, since carnivores characteristically have very large home ranges, no identification of especially sensitive habitat areas is feasible, except likely denning sites in rocky slopes and cliffs. Like the raptors, carnivorous mammals would suffer from the ecological imbalance that would result if prey populations were reduced. Trapping results indicate large populations of small mammals, whose numbers could be greatly reduced at the loci of operations. Some vegetative recovery would take place at disturbed sites during the life of the project. After closeout and restoration, habitat recovery will eventually allow animal populations to recover to approximately the present levels.

Other Large Mammals. Burros present a special problem in the Coso area in that they are already causing a negative impact on wildlife habitat. At present, burros congregate around water produced by steam condensate from Coso Hot Springs. Because they are large and abundant, burros may well become a nuisance during geothermal development. They may constitute a menace on roads, and they can also destroy light fencing, if it denies them access to water or preferred forage. Burros reportedly damage pipelines, especially if attracted by small leaks. They may bump into sensitive equipment during fights, and their trampling in areas of heavy use causes compaction of soils.

Small Mammals. Perhaps the most severe direct impacts of habitat removal would be experienced by small mammals. Some rodents, if they are not hibernating or aestivating below ground, could move to nearby areas. However, the newly colonized areas may already be at carrying capacity and unable to support the additional populations. These smaller animals depend on relatively small areas of habitat for food and cover as compared to raptors, carnivores and burros, thus are most severely affected by habitat loss. They will also be disturbed by noise, as discussed above.

Herpetofauna. In addition to the impacts of noise, reptiles and amphibians, like small mammals, may be accidentally crushed by vehicular traffic. Amphibians also experience habitat loss from any sustained reduction or loss of surface moisture.

Aquatic Species. Fish and aquatic invertebrate species occur in two localized habitats: Little Lake and Haiwee Spring. These aquatic fauna will be affected if water tables drop due to excessive ground water pumping. As documented in Section 2.5.2 and the Hydrology Technical Report, springs which feed Little Lake may be lowered as a result of the proposed action; see Wildlife discussion on Resource Utilization phase. See also Section 2.8.2.1.

2.7.2.2 Areas of Sensitivity Within CGSA

Figure 2.7.2-1 indicates wildlife habitat areas in and adjacent to the CGSA which are sensitive or unique; these are summarized below.

A. Little Lake, just outside the CGSA, in an area of unknown geothermal potential, is a fresh water habitat nearly unique within the region; the riparian vegetation and the fauna depending on this vegetation are vulnerable to any reduction of water levels. The cliffs along the eastern lake border extend into the CGSA (into a zone of unrated geothermal potential); these cliffs provide likely nesting sites for raptors and possibly some carnivores. At least one pair of prairie falcons was observed nesting there in the spring of 1979.

B. Haiwee Spring is the only other permanent fresh water source in the immediate vicinity of the study area. Like Little Lake, it provides valuable habitat for many species inhabitating the CGSA.

C. Ephemeral playa lakes east and north of Red Hill are occasionally important sources of fresh water (Geothermal Zones 3 and 4), as are desert washes, found throughout the area.

D. The mountains between and including Volcano Peak and Sugarloaf Mountain (Zones 1, 2 and 3) are the loci of raptor sightings (including hawks and golden eagles) and provide probable nesting sites for raptors. These and other mountainous regions within the CGSA also provide likely carnivore denning habitat.

E. Transmission lines and power pylons through Rose Valley provide roosting for raptors (Zones 3 and 4 and unrated geothermal zones).

F. Rocky ridges near Joshua Tree Woodland, at the extreme northern edge of the CGSA in a zone of unrated geothermal potential, provide likely raptor nesting sites.

G. Lava cliffs southeast of Coso Hot Springs (Section 15, T22S, R39E) on the eastern border of the CGSA in Zone 3 are likely raptor nesting sites.

H. Joshua Tree Woodland provides good habitat for the Mohave ground squirrel. In addition, birds occur in large numbers and diversity. Although usually not dense, this habitat type exists in many places throughout the study area. It is usually found in alluvial surfaces and seldom on shallow stony-soil slopes. Relatively good stands exist east of Cactus Peak in Zone 3 (Sections 20 and 30, T21S, R39E), northeast of the pumice mine and near the petroglyphs in Zone 3 and an unrated area (Section 14 and 15, T21s, R38E), along the road east of Red Hill in Zones 3 and 4, and in the mountains north

I. Coso Hot Springs in Zone 1 is frequented by many species as a water

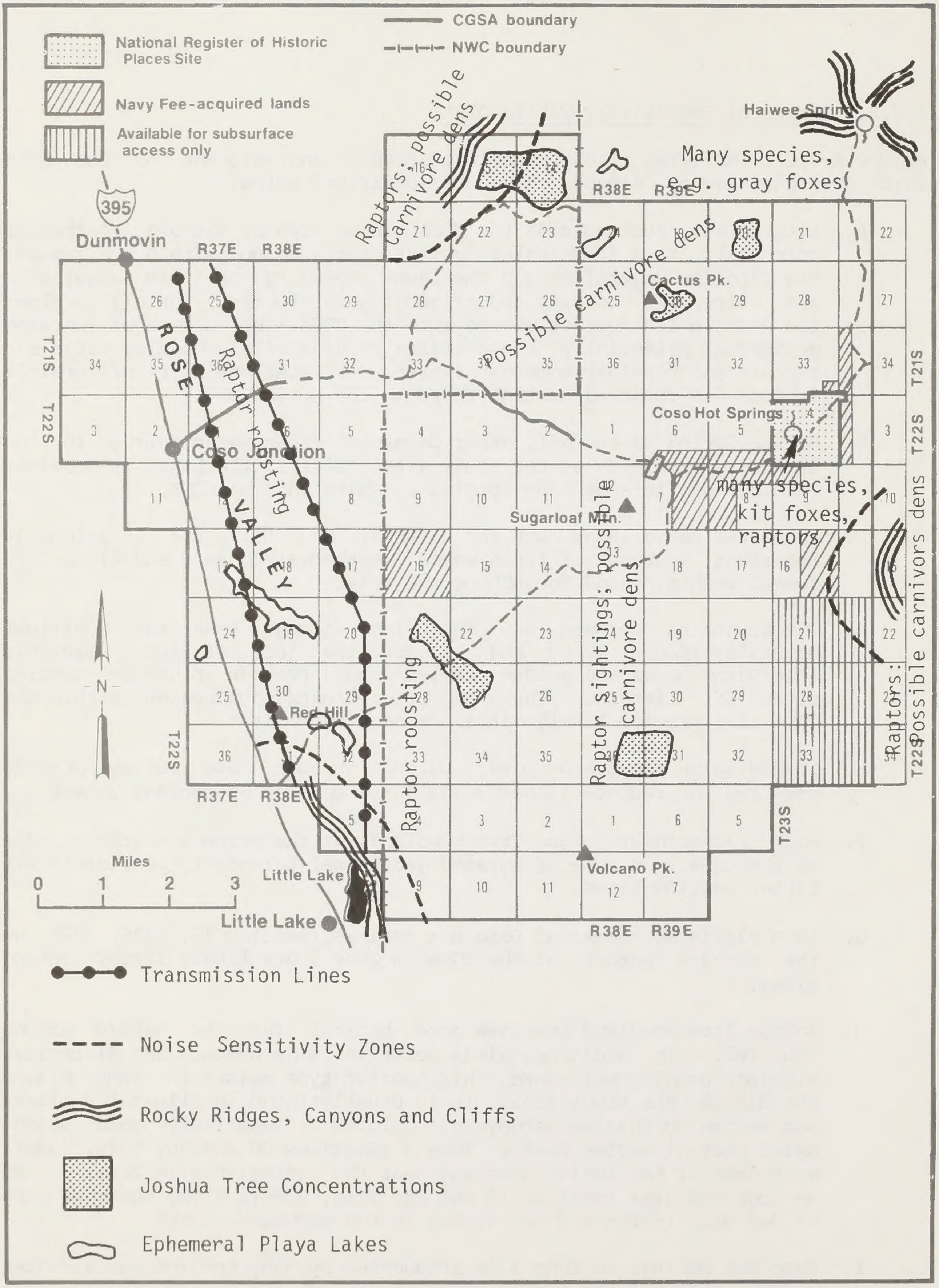

Figure 2.7.2-1. SENSITIVE WILDLIFE HABITAT AREAS OF CGSA

source. The area is a National Historic Register Site, is NWC fee-owned land and is protected from surface disturbance of current NWC policy. As habitat, the site is poor, partly as a result of trampling and compaction of soil.

Areas not shown on Figure 2.7.2-1 as special habitat features can be considered as moderate to low sensitivity areas, pending further detailed investigation. For example, Mixed Desert Scrub, Creosotebush Scrub and Shadscale Scrub characterize much of Zones 1 and 2, where geothermal development is expected to be concentrated. Such vegetation affords moderately good habitat for many wildlife species. No wildlife species were found to be restricted to these two geothermal zones. The wide distribution of these vegetative associations throughout the CGSA (and the equally wide distribution of the one rare faunal species encountered in Zone 1 and 2, the Mohave ground squirrel) would suggest that this complex could be considered as a relatively low sensitivity habitat. However, detailed site specific studies undertaken later as part of the permitting process may uncover new information on areas not now known to be sensitive.

The remainder of the CGSA is rated to have marginal (Zone 3) or uncertain (Zone 4) potential as a geothermal resource; no wildlife species were found to be restricted to these portions of the CGSA.

One further caution should be entered, concerning the slow recovery rate of all desert habitat, once disturbed. In this sense, the entire CGSA should be considered sensitive, and the features noted on the foregoing map should be regarded simply as more sensitive than other habitats in the study area. Finally, the CGSA as a whole must be perceived in perspective in relation to the surrounding region, which affords many similar habitats, the only exception being oases; thus, Little Lake and Haiwee Spring assume additional importance as areas to be protected. (Coso Hot Springs, as noted, will be excluded from habitat disturbance resulting from the proposed action.)

2.7.2.3 Rare, Threatened and Endangered Species

Probably the most important wildlife issue in the GCSA involves the Mohave ground squirrel which is designated ~~is~~ as "rare" by the California Fish and Game Commission. The species is numerous in every habitat of the CGSA except steep, rocky slopes. The highest densities were observed in Rose Valley and on the Sierra slope west of US Highway 395. Since this species occurs in almost every part of the CGSA, it will be very difficult to carry out geothermal exploration and development without causing some adverse impacts. This is particularly true because the areas of relatively level terrain favored by these animals may also be the best sites for geothermal facilities, e.g., in geothermal Zones 1 and 2. See Chapter 3 (Mitigation Measures) and the Flora and Wildlife Monitoring Plan in Appendix D. The ringtail, a carnivore, protected under California law, probably utilizes all CGSA habitats; denning sites would be expected in rocky hillsides and cliffs. No

Blue List species are expected to be significantly affected.

2.7.2.4 IMpacts During Stages of Geothermal Development

Preliminary Exploration. In the first few years of the program, exploration will be largely confined to Zones 1 and 2.

Microseismicity and resistivity measurements would involve some off-road driving. The extent of this is expected to be minimal in Zone 1, as sufficient data may have been developed by the NWC contractor. Off-road travel will cause some minor destruction of wildlife and habitat; types of surface disturbance include vehicle tracks, tire ruts and wheel holes (Davidson and Fox, 1974). Refer also to Section 2.6.2.1, Soils.

Some wildlife habitat will be lost due to vehicular traffic and drilling of heat flow measurement test holes. However, the area disturbed by actual drilling would be only approximately 10 square meters per drill hole; no drill pad is required. Again, few such measurements are expected to be necessary in Zone 1. The amount of surface disturbance in this zone would probably amount to no more than 10 acres, total, for off-road vehicle tracks, and less than one-half acre for heat flow holes. More extensive exploration activities of all the types described above are anticipated for Zone 2; in these nine square miles, surface disturbance might amount to three or four times as much as described for Zone 1. The major type of habitat lost in both zones would be Mixed Desert Scrub; specific areas disturbed would be small and localized. Wildlife displaced (particularly rodents and herpetofauna) would attempt to reestablish in nearby areas, which may be presently supporting optimum numbers of these species; some temporary reduction of populations would probably occur.

In Zones 3 and 4, far more extensive preliminary exploration may be necessary; the habitats disturbed could include every type encountered within the CGSA.

In addition to habitat removal, vehicular and drill noise and human presence could prevent raptors and mammalian carnivores from foraging in areas being explored. These localized habitat disruptions, though minor, could possibly also interfere with the feeding or nesting activities of many smaller bird species. Heavy vehicular traffic could disturb some terrestrial vertebrates. Rabbits and snakes may be killed by vehicles on roads, and some rodents could be crushed in burrows by off-road traffic.

Exploratory Well Drilling. During this stage, habitat loss and disturbance to wildlife would be increased. Additional access roads would be cut, drill pads cleared, sumps and disposal pits constructed. During the well drilling phase, noise levels will be high (see Table 2.3.2-1, Noise from Construction Equipment). Birds and mammalian carnivores will avoid drilling areas (P. Leitner, 1979, personal communication). Total area temporarily disturbed by noise and human presence may be as much as one-half mile radius around each drill area (D. White, 1979, personal communication).

Both birds and mammals may attempt to drink from water of sumps or disposal areas (reserve pits) which could contain high concentrations of sálts or toxic substances when wells are first flowed. The nature and degree of effects are unknown. Birds are often attracted to such open bodies of water (even wet mud) in dry areas and may attempt to land and feed or rest on these toxic wet areas (Clemens, 1954; Land, 1974).

Habitat loss is probably a more serious impact than those described above. Exploratory, production and replacement wells each require approximately 4.5 acres/well total surface disturbance. (Subsequently, an average of three additional well-heads may be placed on the same drill pad, using the same sumps, etc.; see Chapter 1.) It is expected that ultimately 600 wells would be drilled in Zones 1 and 2; if 100 of these are drilled in the exploratory period, total disturbance would be 25 x 4.5 acres or 112.5 acres. Animals migrating away from construction sites might not be able to crowd into adjacent areas because the carrying capacity of those areas would be stressed. Loss of habitat means that animal populations would temporarily decline to a new lower level which the remaining vegetation is capable of supporting. Estimates of population reduction for various species would depend upon exact locations of activities and upon habitat type.

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In Zones 3 and 4, some 900 wells are ultimately envisioned. If 300 of these are exploratory, disturbance would be 75 x 4.5 acres, or 338 acres. Habitat disturbed/destroyed could include all types encountered in the CGSA.

Field Development. Power plant construction would affect wildlife due to increased noise, human presence and loss of habitat. Construction activity would temporarily displace raptors and mammalian carnivores. Any construction within one-half mile of nests of sensitive species such as prairie falcons would interrupt nesting (D. White, 1979, personal communication).

Field development would involve approximately 800-1000 acres of disturbance. Habitat removal would be approximately double the amount described for Stage 2 above (exploratory well drilling); the types and habitat disturbed would be as above for all geothermal zones.

Construction of transmission lines and maintenance roads along these lines would involve some clearing of habitat. Vasek, et al. (1975b), report that power transmission lines may increase plant growth in some instances and perhaps offset this loss of habitat. There appears to be generalized decrease in plant densities under the pylons while an increase in plant productivity occurs under the wires and along access roads (Johnson, et al. (1975). Increased diversity of species, as well as more luxuriant plants, have frequently been observed along roadsides, due to increased runoff. The species encountered include some non-native weeds but these are generally outnumbered by native plants.

Resource Utilization. During this stage, the aquatic habitat at Little Lake may be affected if ground water levels are lowered. As mentioned in the hydrology section (see Table 2.5.2-1), projected water use exceeds recharge levels estimated for the Rose Valley area. According to W.R. Moyle of the USGS (1979, personal communication), the level of Little Lake dropped approximately three feet (1 m) below its present level during the drought of 1975-76. Since Little Lake is fed by springs which issue near its water level and since it is a very shallow body of water, lowered ground water levels from water use in excess of recharge volumes could reduce spring flows and return the lake to a marsh. On the basis of estimates produced in this study and past records (level of Little Lake in 1975-76 drought), there is a high probability that the utilization of 6,600 acre-feet of water per year in Rose Valley (see Section 2.5.2) will lower the lake level.

Since Haiwee Spring is higher in elevation than the probable geothermal resource (Zones 1 and 2), it has a low probability of being affected by utilization of that resource (See Hydrology Technical Report).

Additional road construction, exploration, replacement well drilling and additional power plant construction would continue during operation. In all, an additional 600-800 acres may be disturbed as a result of these activities, causing some losses in all habitats throughout the four zones of the CGSA.

Transmission lines can also damage birds. Birds, especially raptors, may be electrocuted. As many species including ravens and golden eagles utilize lines as roosts. Collision of all species with towers or lines may occur, especially night-migrating species (Thompson, 1977).

Close-Out. In the close-out stage, power plant units would be removed, wells capped and sumps and disposal pits returned to natural grade. Noise and increased human presence would be similar to levels during the field development phase. Once facilities are removed, noise and traffic would return to present low levels. Habitat would gradually recover over a period of several decades, and wildlife populations would again increase to approximately their present levels.

2.7.2.5 Cumulative Impacts

All of the impacts described above would also accompany the NWC development program. However, many roads will be shared, and estimated habitat disturbances for the NWC power unit are included in this analysis (see Chapter 1). The greatest cumulative impact would occur during Navy plant construction (assuming active exploration and well drilling are then taking place in BLM-leased lands) and during field development on BLM-leased lands. A total of approximately 2,260 acres of various kinds of habitat could be destroyed as a result of the BLM and NWC development programs; this represents approximately 3 percent of the total acreage of the CGSA. Probably about half of the BLM development as well as most of the NWC development would take place in Zones 1 and 2, which are characterized largely by Mixed Desert Scrub habitat. Additional Scrub will certainly comprise some of the disturbed areas in Zones 3 and 4.

Development is not expected to take place at Little Lake, Haiwee Spring, or Coso Hot Springs; rather, it is the possible lowering of water levels that is of concern in regard to these areas. Remaining habitat types and features, particularly Joshua Tree Woodland and mountainous areas affording raptor and carnivore habitat, can be protected with proper development planning. The status of the Mohave Ground Squirrel will be a matter of continuing concern. The remaining concerns are the potential loss of overall biological productivity of the area and the temporary unbalancing of predator-prey relationships that could result from the loss of even a small percentage of habitat in a fragile desert ecosystem.

no mention of mitigation

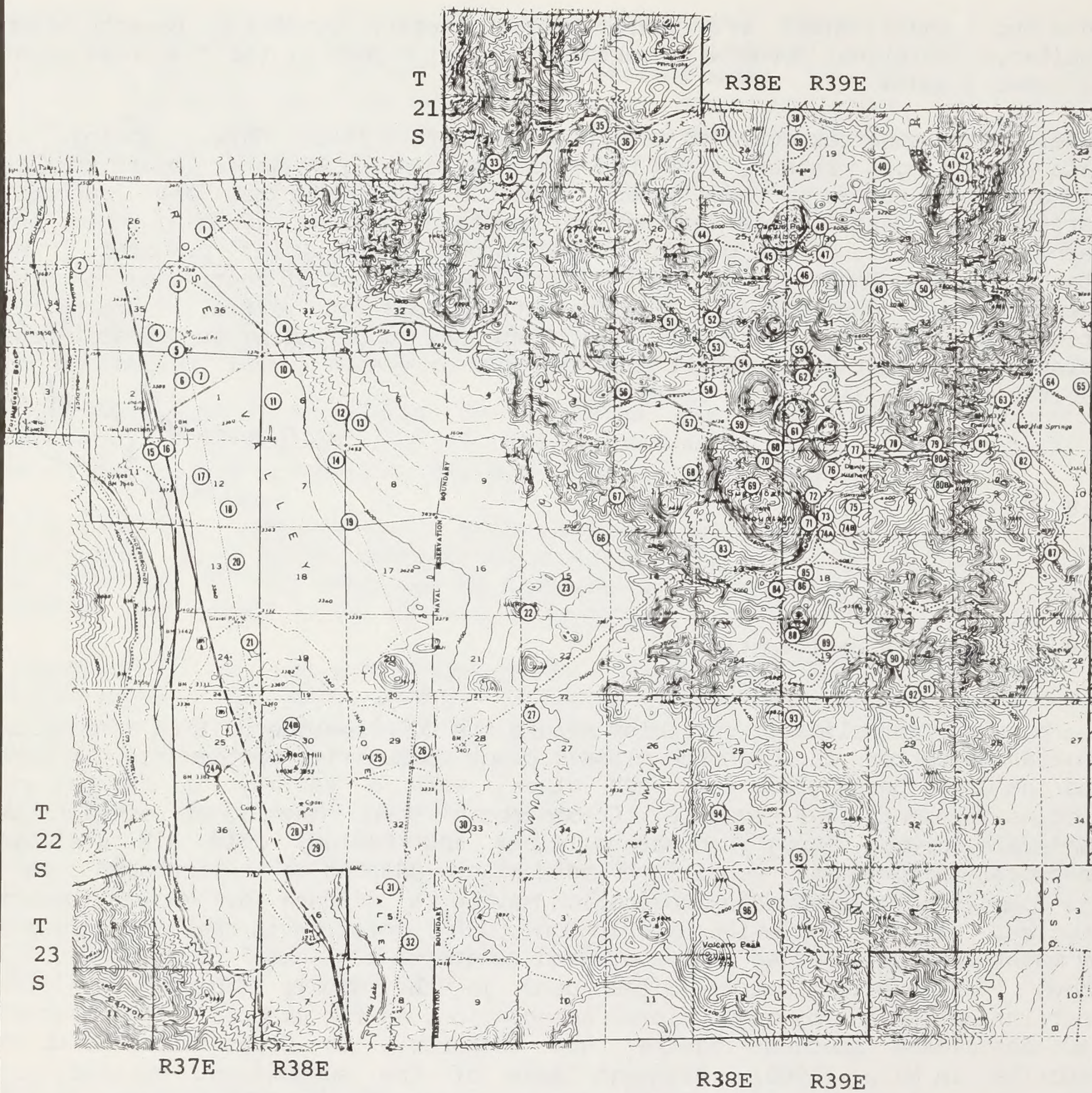
2.8 FLORA

2.8.1 Present Floral Setting

The physical and climatic variables within the CGSA combine to form a complex vegetative pattern in which the classic plant communities of the Mojave Desert and the Great Basin grade into each other, with a variety of subdominant species present (for example, Creosotebush Scrub may occur mixed with Shadscale Scrub). Also, in numerous sinks and basins, cold air drainage produces microclimate conditions where plants adapted to the northern desert are found, while surrounding vegetation may be a mixture of Mojave Desert species. In the following description, CGSA vegetation is therefore grouped by major dominant species and associated subdominant plants. Figure 2.8.1-1 shows locations of sample sites used in the study. Where possible, a correlation is made by vegetational association, as for example, Creosotebush and associated species together are comparable to Creosotebush Scrub as described in Munz (1968), although some of the subdominant species are different. A species list of the vascular plants of the CGSA is found in the Flora Technical Report.

2.8.1.1 Dominant Component Plant Associations

Creosotebush - Burro weed Scrub - The most common plant throughout the Mojave desert is creosotebush (*Larrea tridentata*), occurring over about 70 percent of its total area (Shreve, 1942). On the CGSA, creosotebush occurs mainly with burro weed (*Ambrosia dumosa*), and numerous subdominant species; the resulting



<u>EXPLANATION</u>

Distribution of quantitative sample sites in CGSA. Numbers are arranged from north to south in Rose Valley and north to south in area east of Rose Valley.

Figure 2.8.1-1 CGSA VEGETATION SAMPLE SITES association is termed Creosotebush - Burro weed Scrub. It is present on the slopes of the Sierra Nevada west of Highway 395 on the east side of Rose Valley up to an elevation of about 4000 feet, and in the southeastern portion of the CGSA. The burro weed component occurs mainly on coarse, sandy soils bordering Rose Valley and in the far southeastern corner of the CGSA. (See Figure 2.8.1-2 and 2.8.1-3).

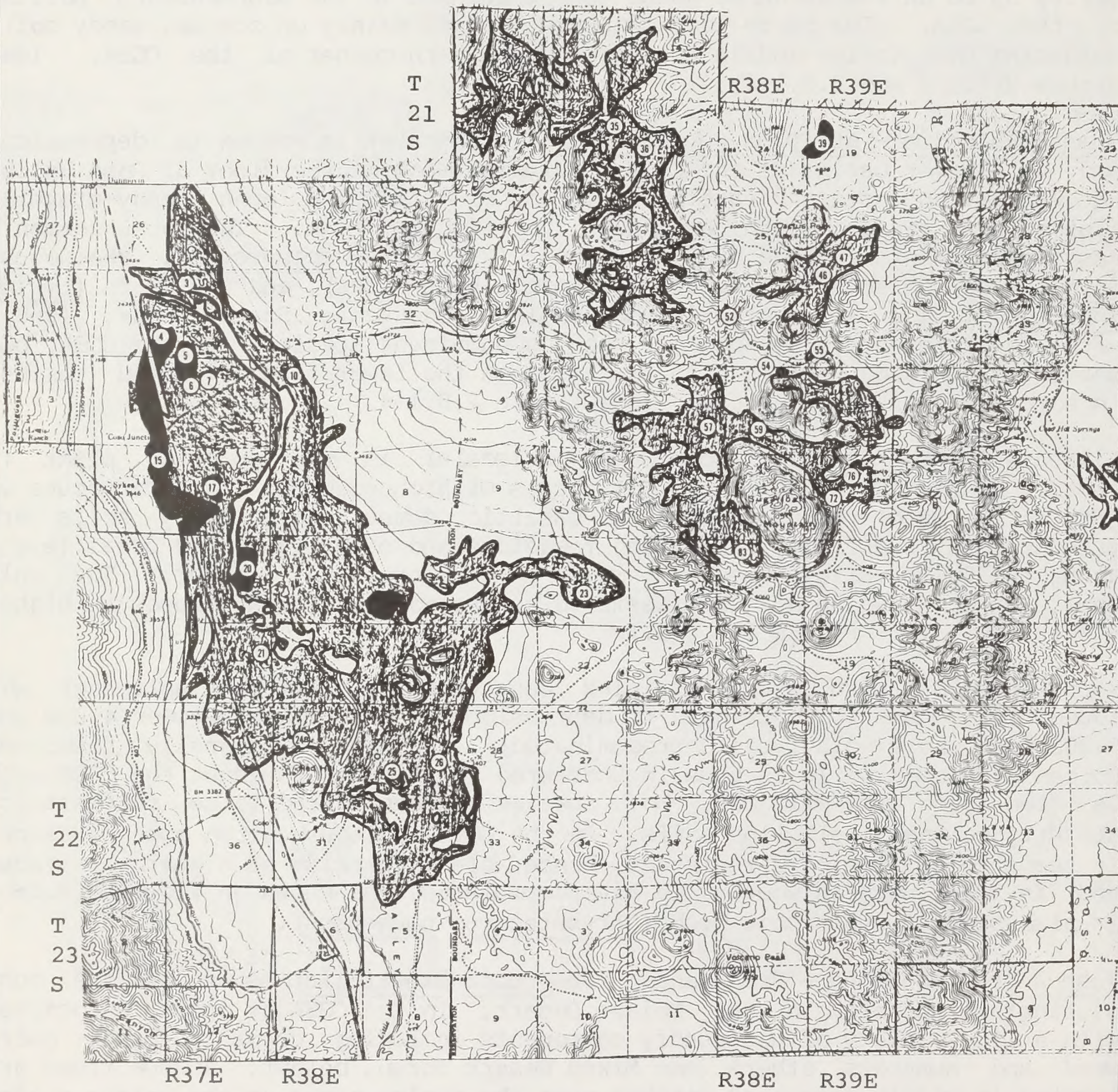
Shadscale Scrub - Atriplex confertifolia (shadscale) is common in depressions and as larger basins of the CGSA, including much of the floor of Rose Valley the vegetation north and east of Sugarloaf Mountain, and open sandy-gravelly slopes and ridges south and north of Cactus Peak. The most commonly associated plants include bud sagebrush (Artemisia spinescens), cheesebush (Hymenoclea salsola), ricegrass (Oryzopsis hymenoides), and box-thorn (Lycium andersoni). The association is comparable to Shadscale Scrub (Munz, 1968), with a difference in some of the subdominant species. On the CGSA, bud sagebrush is found usually with shadscale on the lower flat areas and basins; in some areas it occurs alone. (See Figure 2.8.1-4.)

Allscale Scrub - Atriplex polycarpa (allscale) is the dominant plant in certain sandy arroyos, where it occurs with cheesebush. It also occurs in Rose Valley in clay sink areas; on basaltic domes where sandy soils are present; on lava flows; and along roadsides and other disturbed areas (e.g., along the Owens valley aqueduct), where it develops as a pioneer. The only habitats from which allscale seems to be excluded are rocky slopes at higher elevations. (See Figure 2.8.1-5.)

Four-winged Saltbush Scrub - Atriplex canescens (four-winged saltbush) was found to be mostly restricted to depressions at elevations between 4,000 and 5,000 feet where clay soil predominated; it was occasionally found on volcanic slopes. It is thus in scattered locations throughout the CGSA. It is often found with allscale. Both species are considered to be tolerant of slightly saline or alkaline soils. On the CGSA, saltbush often appears alone. It seems to be more cold-resistant, hence able to persist at higher altitudes and in small pockets where cold air accumulates. As shown in Figure 2.8.1-6, it also occurs with rabbit bush (Chrysothamnus nauseosus).

Joshua Tree Woodland - The Joshua tree (Yucca brevifolia) is one of the most distinctive plants in the Mojave Desert. In the CGSA it occurs associated with a wide variety of understory components including creosote bush, burro weed and numerous others (see Mixed Desert Scrub, below). Joshua trees are located in widely scattered patches near the pumice mines at the northern edge of the CGSA, in the vicinity of Cactus Peak, and in a number of small areas between Volcano Peak and Sugarloaf Mountain. They also occur on both sides of Cinder Road east of Red Hill. Comparison of Figure 2.8.1-7 with preceding illustrations will show that Joshua trees (the term Joshua Tree Woodland is commonly applied virtually wherever the species is found) actually occur together with various other species and associations within the CGSA.

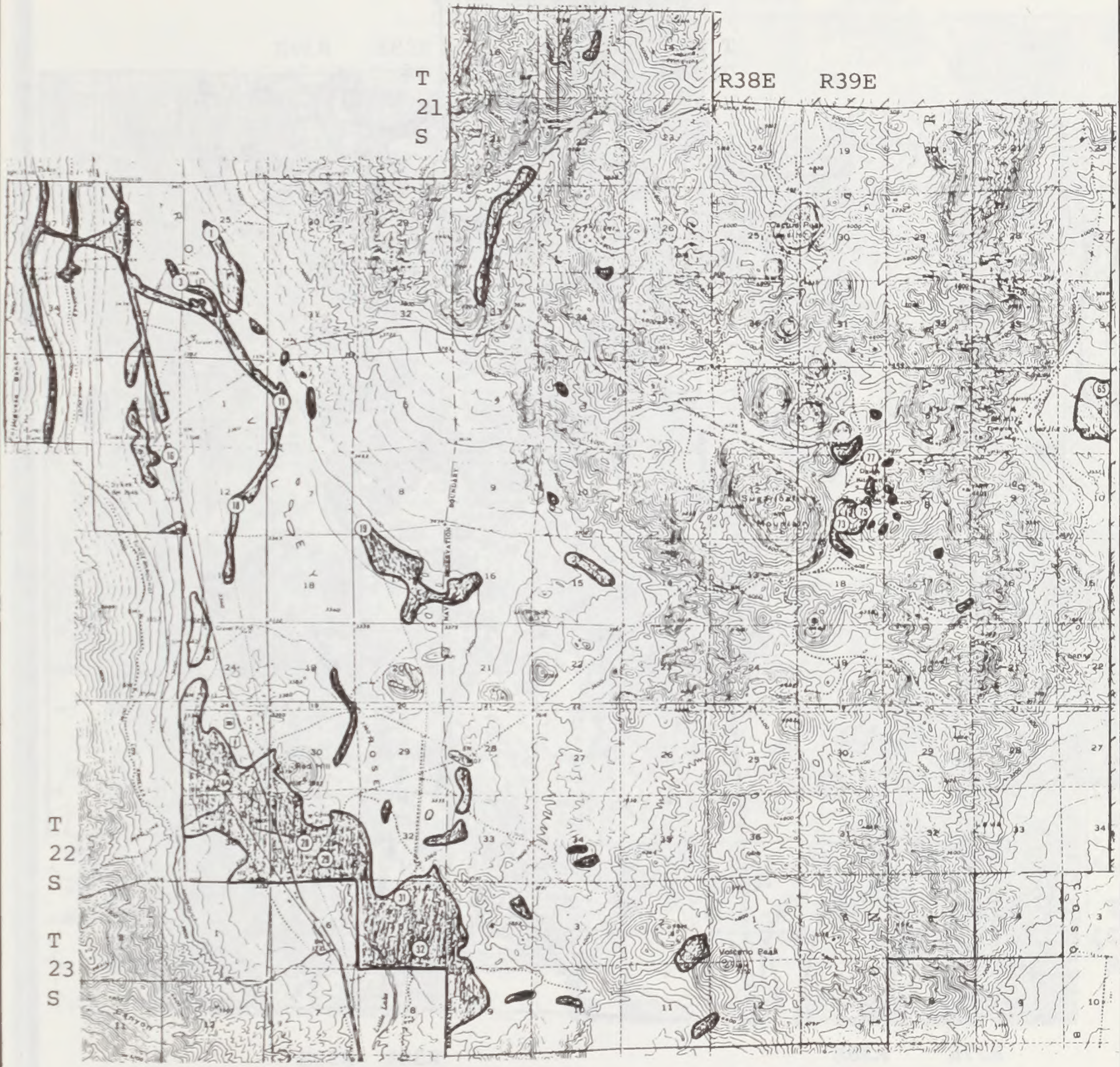
Two other associations which are important (but which have no one species that characterizes them) are Mixed Desert Scrub and Alkali Sink Brush. One



EXPLANATION

Distribution of Atriplex confertifolia (shadscale), shaded, and Artemisia spinescens (bud sage), solid, in the CGSA. Sample sites are indicated by numbers. See Table 4 for data.

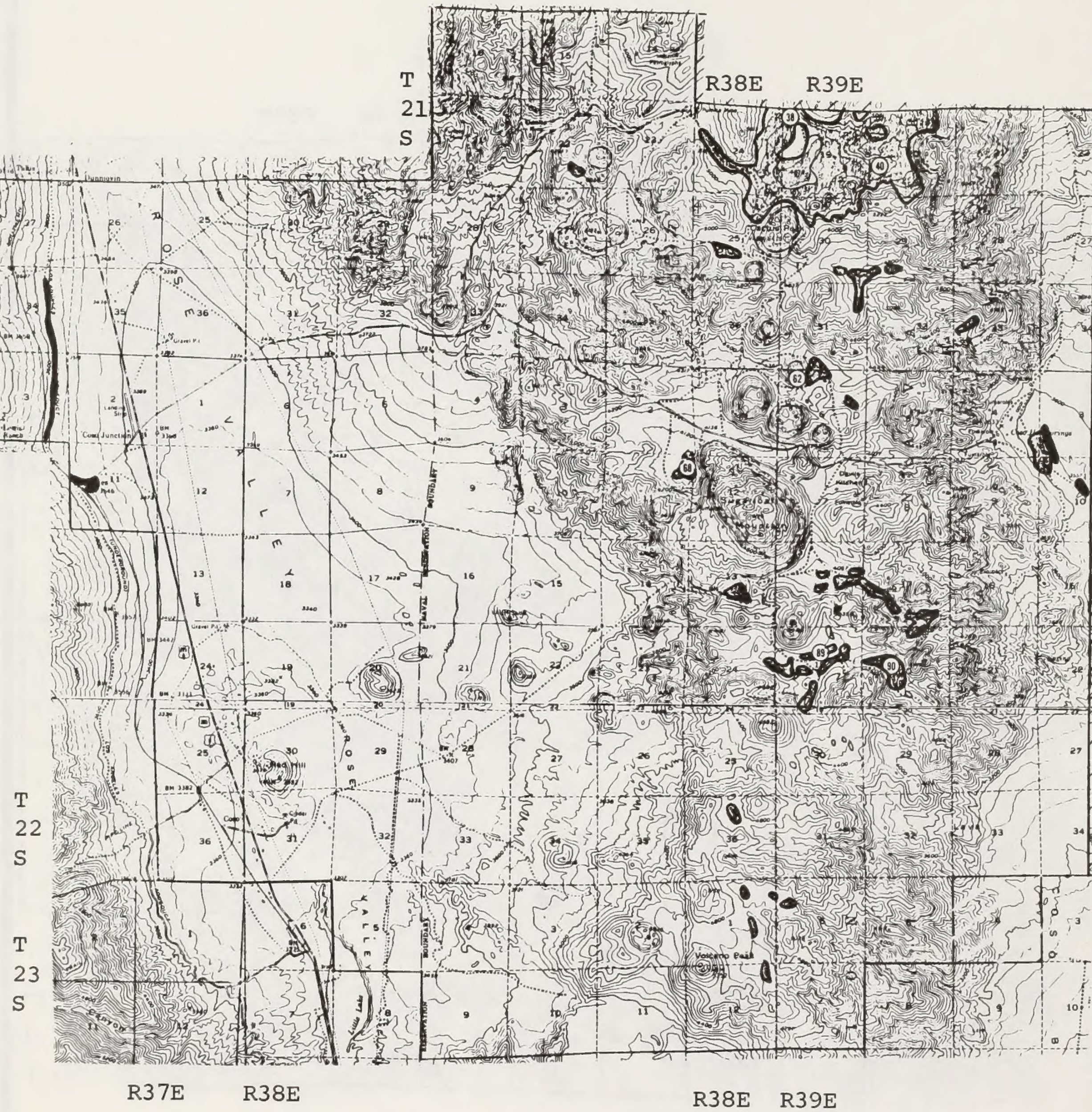
Figure 2.8.1-2 DISTRIBUTION OF SHADSCALE AND BUD SAGE



EXPLANATION

Distribution of Atriplex polycarpa (allscale) in the CGSA. Sample sites are indicated by numbers. See Table 5 for data.

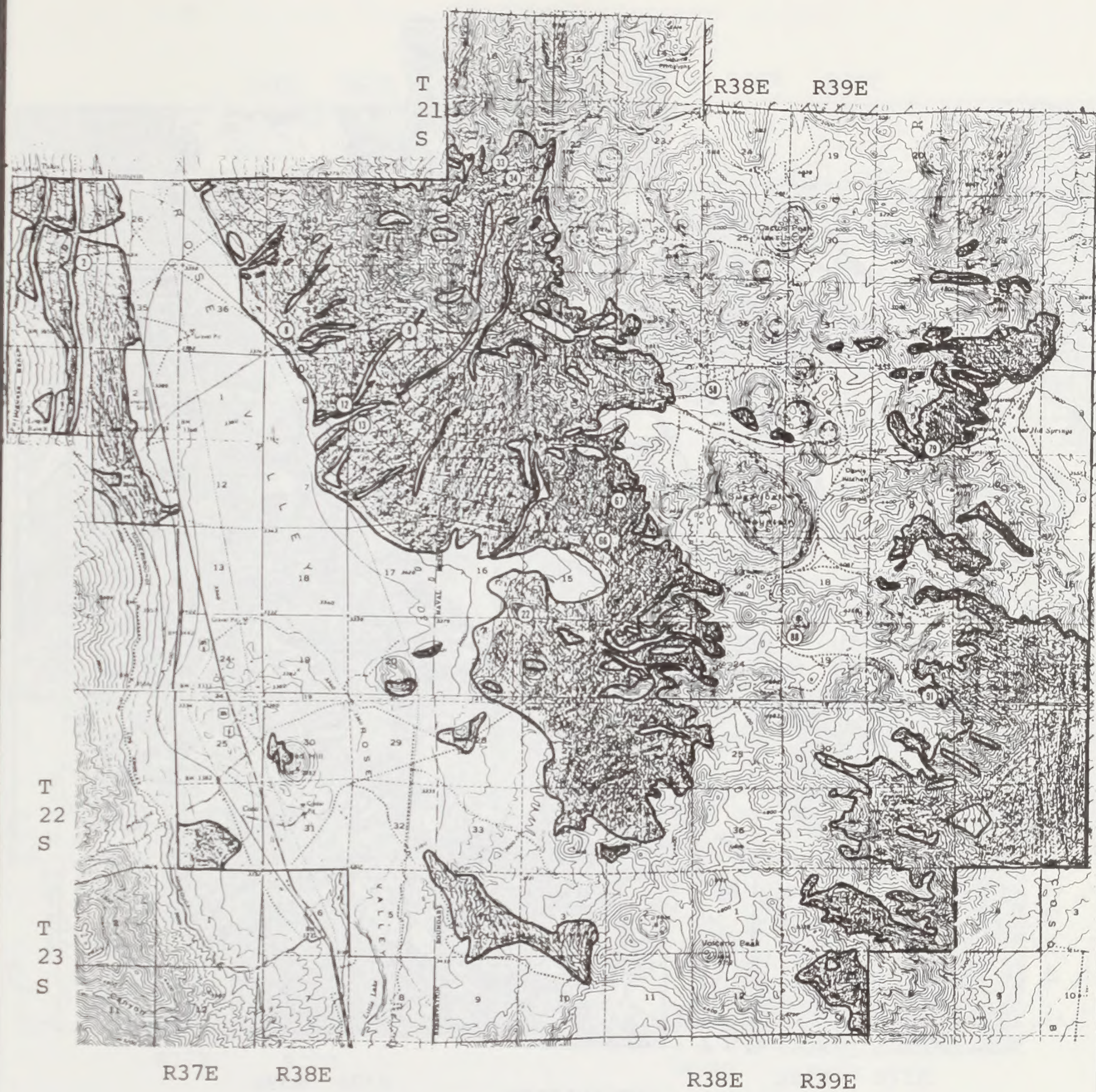
Figure 2.8.1-3 DISTRIBUTION OF ALLSCALE



EXPLANATION

Distribution of Atriplex canescens (four-winged saltbush), shaded areas, and Chrysothamnus nauseosus (rabbit bush), solid, in the CGSA. Sample sites are indicated for Atriplex canescens by numbers. See Table 6 for data.

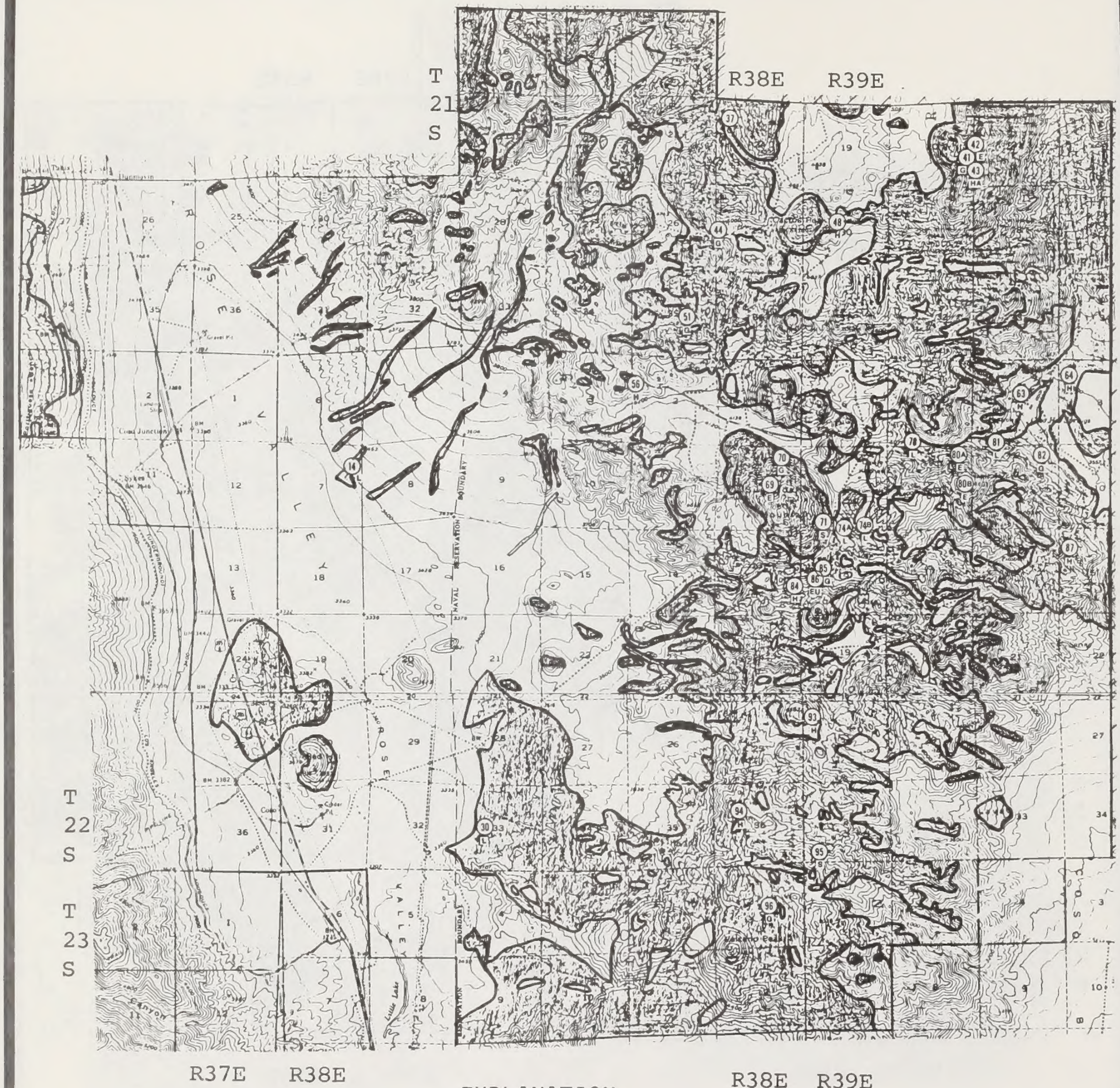
Figure 2.8.1-4 DISTRIBUTION OF FOUR-WINGED SALTBUSH AND RABBIT BUSH



EXPLANATION

Distribution of Ambrosia dumosa (burro weed) in the CGSA.
Sample sites are indicated by numbers. See Table 7 for data.

Figure 2.8.1-5 DISTRIBUTION OF BURRO WEED



EXPLANATION

Distribution of Mixed Desert Scrub on the CGSA. Sample sites are indicated by numbers. Dominant species for each site is indicated by the following subtending letters. (See Table 8 for data.)

- L   *Larrea tridentata* (creosote bush)
- H   *Hymenoclea salsola* (cheesebush)
- G   *Grayia spinosa* (hop sage)
- E   *Eriogonum fasciculatum* var. *polifolium* (California buckwheat)
- EU   *Eurotia lanata* (winter fat)
- S   *Stipa speciosa* (needle grass)
- HA   *Haplopappus cooperi* (Cooper's goldenbush)

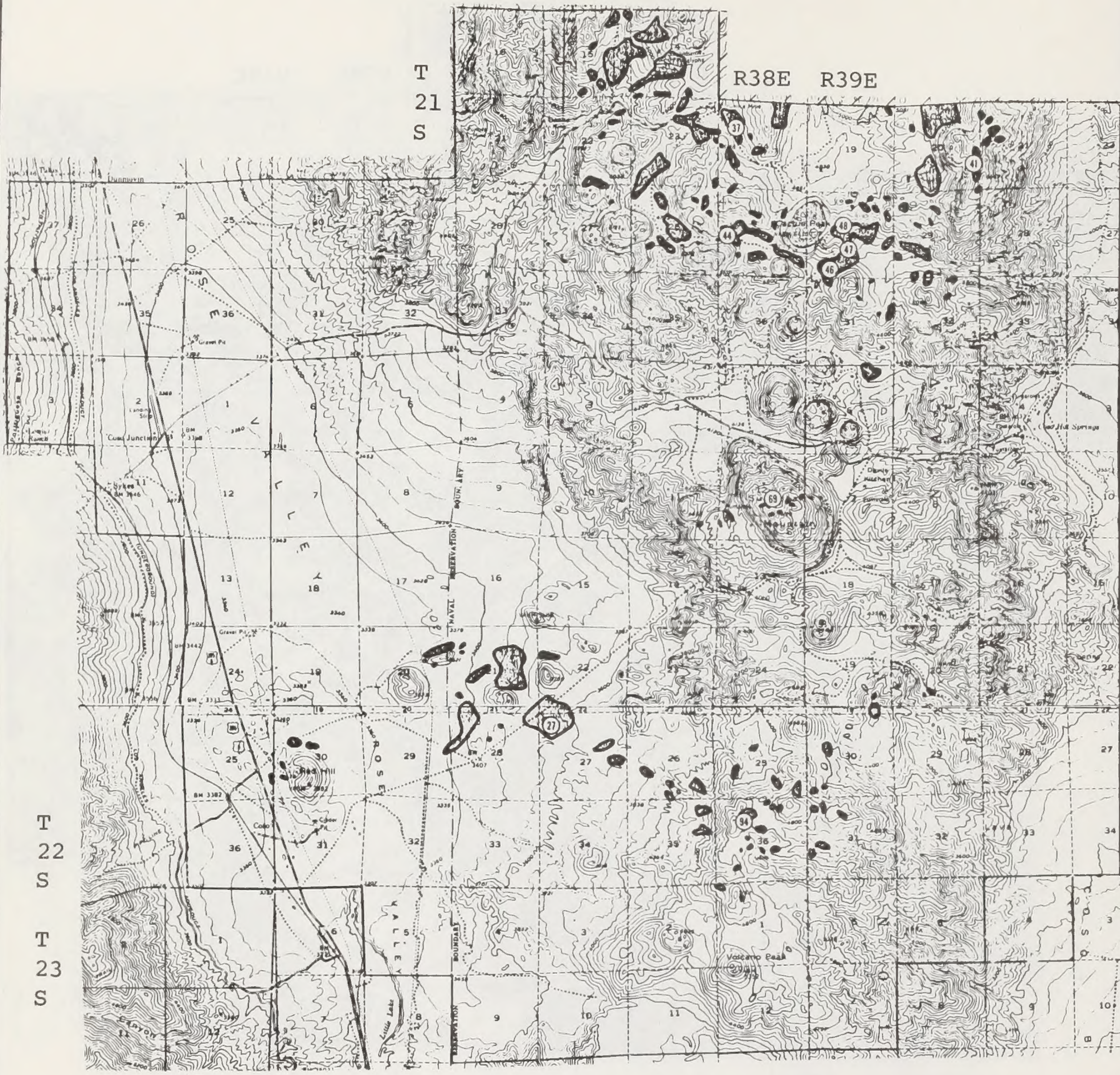
Figure 2.8.1-6 DISTRIBUTION OF MIXED DESERT SCRUB

EXPLANATION

Distribution of Larrea tridentata (creosote bush) in the CGSA. Sample sites are indicated by numbers. Subdominant species at each site is indicated by subtending letters. Quantitative data are given with understory species in Tables as indicated.

M	Mixed Desert Scrub (Table 8)
AM	Ambrosia dumosa (Table 7)
AT	Atriplex confertifolia (Table 4)
ATP	Atriplex polycarpa (Table 5)
---	Larrea exclusive (Table 7)

Figure 2.8.1-7 DISTRIBUTION OF CREOSOTE BUSH



EXPLANATION

Distribution of Yucca brevifolia (Joshua tree) on the CGSA. Sample sites are indicated by numbers. See Table 9 for data.

Figure 2.8.1-8 DISTRIBUTION OF JOSHUA TREE further, rather complex association is here termed Creosotebush - Mixed Desert Scrub.

Mixed Desert Scrub - At elevations above 4,000 feet, creosotebush is generally replaced by a broad mosaic of species more tolerant of cold winter temperatures and more characteristic of the Great Basin desert to the north and east. The dominant species in this association on the CGSA include cheesebush, hop-sage (Grayia spinosa), California buckwheat (Eriogonum fasciculatum, goldenhead (Acamptopappus sphaerocephalus), Mormon tea (Ephedra sp.), box-thorn (Lycium sp.), and goldenbush (Haplopappus sp.), as well as perennial grasses such as desert needlegrass (Stipa arida) and ricegrass (Oryzopsis sp.). These plants are associated with creosote bush and Joshua tree in other areas of the CGSA as understory species. In the higher elevations, however, the species exist in pure associations. (See Figure 2.8.1-8)

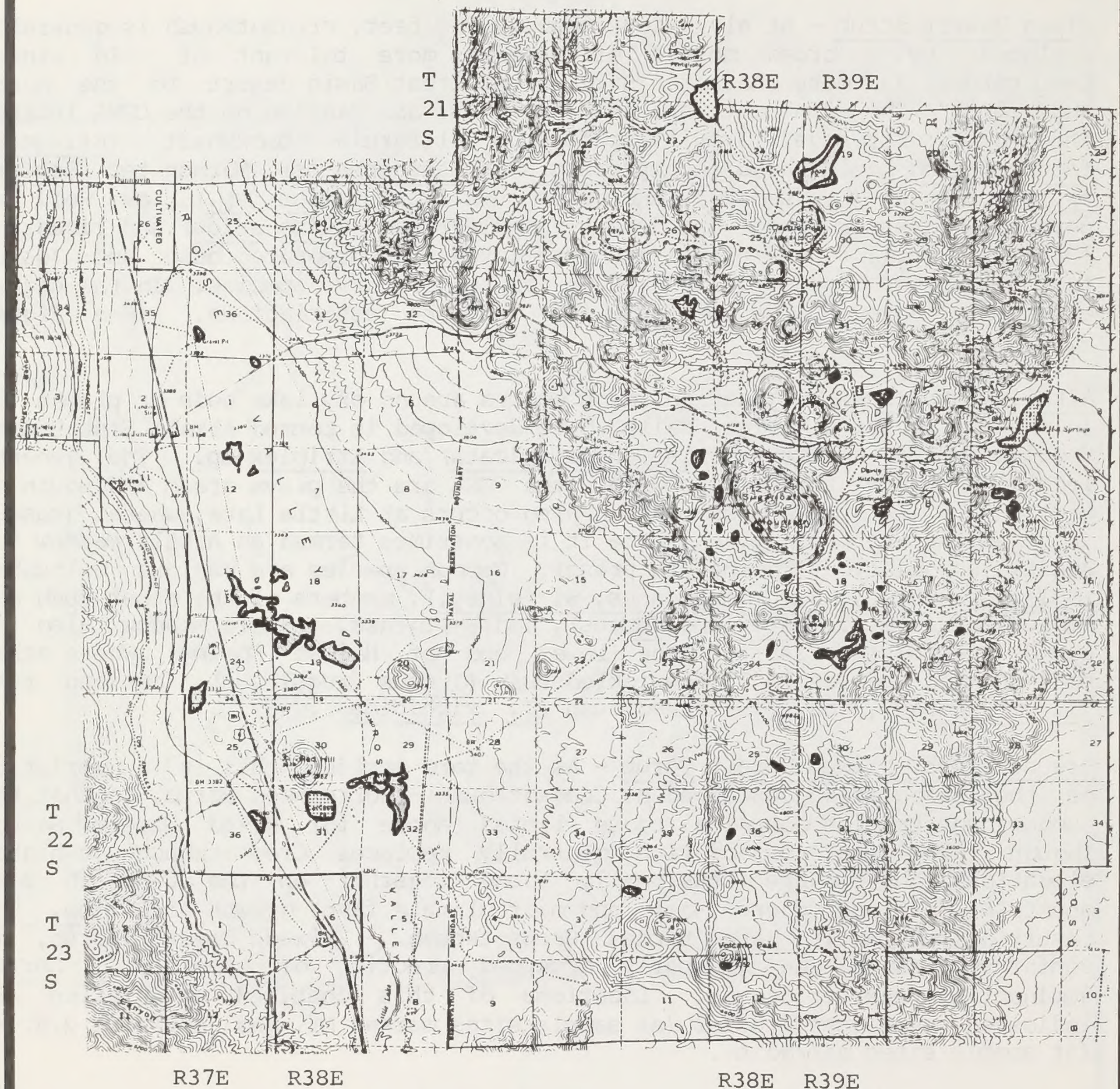
Alkali Sink Brush - Vegetation which occurs around dry lake beds or playas, or in areas where alkaline soils have developed is termed Alkali Sink Brush. Species include saltgrass (Distichlis spicata) and Atriplex sp. The general locations where this occurs within the CGSA are the playa areas and south of Little Lake. A similar association also occurs at Little Lake, where grasses and sedges are present, and here it is sometimes termed an Alkali Meadow and Aquatic association (Thorne, in press). Common species are various bulrushes (Scirpus acutus, S. americanus, S. olneyi), members of the other rush and sedge genera (e.g., Carex and Juncus), and saltgrass. Alkali Meadow also is found in moist areas at the lower end of Haiwee Spring, where other semi-aquatic species include wrinkled rush (Juncus rugulosus), Mexican rush (J. mexicanus), and Iris-leaved rush (J. xiphioides).

Creosotebush - Mixed Desert Scrub - As the term implies, this is a variation on the association described as Creosotebush - Burro Weed Scrub, in that the subdominant species comprise those listed above for Mixed Desert Scrub. Though the latter association generally replaces Creosotebush at higher elevations, the two are occasionally found together on the CGSA on some mountainous areas where soil and microclimate favor growth of Larrea. The resulting complex is here termed Creosotebush - Mixed Desert Scrub, in conformance with the generally accepted practice of considering Larrea dominant wherever it occurs. Locations of this combined association are indicated in Figure 2.8.1-2 (at sample sites marked M), and in Figure 2.8.1-8 (at sample sites marked L).

2.8.1.2 Cultivated, Disturbed, Open, and Barren Areas

In addition, there are several areas within the CGSA that are devoid of a natural overstory of vegetation (see Figure 2.8.1-9). These include:

Cropland - Alfalfa is grown at Rose Valley Ranch, where approximately 400 acres are irrigated.



<u>EXPLANATION</u>

Distribution of disturbed, cultivated, open and barren areas in the CGSA.

Disturbed areas (coarse dots)
Cultivated areas (so noted)
Open flats (shaded)
Barren flats (fine dots)

Some disturbed areas have been heavily revegetated; these are not shown in Figure 1.

Figure 2.8.1-9 DISTURBED, CULTIVATED, OPEN AND BARREN AREAS

Disturbed Areas - The Coso Hot Springs area contains more than 40 steam wells, as well as mud pots, fumaroles and small hot pools. Numerous past attempts to develop the site (e.g., as a spa) have left the area greatly disturbed. At present various dilapidated structures remain near the springs along with numerous fences placed around hot pools and fumaroles by the NWC. Also, steam condensate is collected by system of pipes to provide water for cattle. Large numbers of burros have severely impacted the entire area by over-browsing vegetation and compacting soils. However, a number of weedy annuals are fairly abundant in springtime.

Gravel, cinder and pumice mining sites are in a state of recovering from past disturbances; here some native vegetation (frequently allscale, shadscale, and cheesbush) is recolonizing, along with introduced weedy species such as Russian thistle (Salsola pestifera) and sandbur (Cenehrus pauciflorus). At the rest stop at Coso Junction, buildings, irrigated grasses and a stand of over 20 good-sized poplars (Populus fremonti) are present. Other buildings, such as at the Rose Valley Ranch, Lewis Ranch, and west of Coso Junction are surrounded by disturbed areas; introduced species include cypress (Cupressus sp.), cottonwood (Populus sp.), locust (Robinia pseudoacacia), tamarisk (Tamarix sp.), willow (Salix sp.), sycamore (Platanus racemosa), and maple (Acer sp.).

Open flats - There are several local depressions (some less than an acre in extent) among the hills in the eastern half of the CGSA, which are devoid of shrubby species, probably because of soil conditions. Vegetation on these open flats varies, but commonly consists of spring-blossoming annuals such as coreopsis (Coreopsis bigelorii, C. californica), pectocarya (Pectocarya sp.); later, various annual buckwheats (Eriogonum sp.) are prominent.

Barren Areas or Playas - Several of these have developed along the central drainage in Rose Valley; usually playas have a clay surface which cracks when dry. At the periphery of each of these is often a growth of allscale, and less often, shadscale or saltbush. The playas themselves are usually barren.

2.8.1.3 Rare and Locally Endemic Plants

The CGSA, Haiwee Spring, and Little Lake areas contain no plant species, subspecies or varieties noted in the U.S. Dept. of Interior's Fish and Wildlife Service list of threatened or endangered species (USDI, 1976b), or in the California Department of Fish and Game's latest listing (1979). However, there are seven species of special concern. The California Native Plant Society (CNPS) inventory of rare and endangered plants of California (Powell, 1974) lists two species as very rare, and rare and endangered (one category), one as rare but not endangered, and several species as not rare but of limited distribution.

Spartina gracilis (desert or alkali cordgrass); CNPS listing: - very rare, and rare and endangered. This is a semi aquatic plant which occurs in one locality on the western shore of Little Lake (Figure 2.8.2-1).

Pholisma arenarium (pholisma); CNPS listing - very rare, and rare and endangered. This parasite plant has been found (Zembal et al., 1978) in one small locality approximately 140 yards east of the tamarisk tree on the wash just north of Coso Hot Springs (Figure 2.8.2-1). It feeds on roots of other plants, hence maintenance of host vegetation at this locality is important.

Canbya candida (white canbya poppy); CNPS listing - rare but not endangered. This small poppy has been observed in the CGSA in one location south of Cinder Road near Red Hill. distributed but very. infrequent (Figure 2.8.2-1).

Additional species, while not considered rare, are "mostly of limited distribution," as shown in the CNPS listing of 1974; these are:

Eschscholzia minutiflora (small-flowered poppy)

Stylocline micropides (desert neststraw)

Viguiera reticulata (leather-leaved Viguiera)

Although these plants do not occur widely throughout southern California deserts, none are limited to one particular area of the CGSA; therefore, specific sensitive areas cannot be identified for them (Zembal, et al., 1978). The CNPS status of these plants is such that they warrant population monitoring and possible future reassessment of status (Powell, 1974); see also Flora and Wildlife Monitoring Plan in Appendix D.

Additional species known or expected to occur within the area may be placed on the state's rare list; these, of course, would require site-specific identification and monitoring, as would the rare and limited species listed above. For example, the perennial Ripley's cymopteris (Cymopterus ripleyi), known in Nevada but new in California, has been discovered along the western edge of the Coso Range (Munz, 1968: 1030; DeDecker, 1978, loc. cit.). Other similar species which are present in the CGSA are Kirby's spurge (Euphorbia ocellata) and lomatium (Lomatium utriculatum). Heller's bird-beak (Cordylanthus helleri) has not been found in the CGSA but may be present, and would be worthy of monitoring.

2.8.2 Impacts of the Proposed Action on Flora

Impacts were estimated on the basis of field survey data, literature pertaining to local flora, local botanists' input, and Chapter 1.

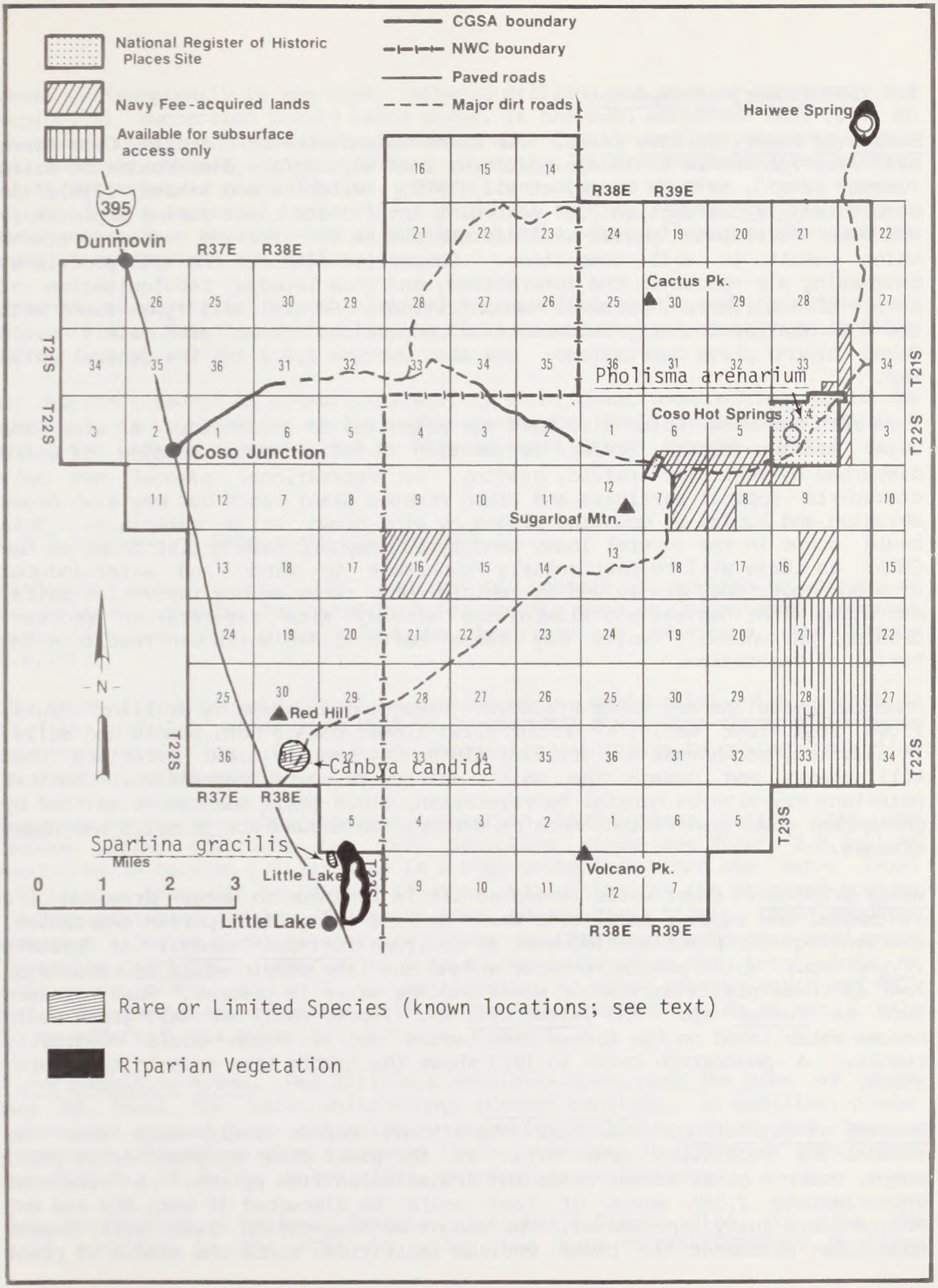


Figure 2.8.2-1. SENSITIVE VEGETATION AREAS IN CGSA

2.8.2.1 Summary of Impacts

Damage to Desert Surface Soils. The plant communities of the arid Coso area are very vulnerable to damage resulting from any surface disturbance of soils (Vasek, et al., 1975a; Vasek, et al., 1975b; Wilshire and Nakata, 1976). As documented in the Section 2.6, vehicular traffic off roads during exploratory and other development phases will disturb plants by creating vehicle tracks which result in soil compaction. Compaction disturbs the soil profile by decreasing air spaces in the interstices, and thus impedes recolonization of native plants (Thorne, personal communication). Several soil types found with the CGSA are particularly vulnerable to compaction. These are mainly soils found around playa depressions; see also Section 2.6.2 and the General Soils Map.

Tire ruts and wheel holes also have the potential to constitute a wind and water erosion hazard (refer to Section 2.6.2). Wind erosion of soils disturbed by vehicular traffic, grading, or vegetational removal not only transports topsoil particles and often exposes plant roots but may also cause abrasion and burial of downwind plants by wind-blown solid materials. This could occur in the several loamy sand types (Maynard Lake soils) found on the CGSA; as these will be particularly vulnerable to wind- and water-induced erosion once they are marked by vehicle ruts. Erosion may impoverish soils, degrading plant habitat and slowing the already slow revegetation process. Grading on unstable soils may cause earth slides which can result in the burial of vegetation.

Chemical Emissions and Waste Products. Breaching of sumps by drilling fluid, fluid from test wells, or uncontrolled flows, damage both plants and soils. In addition, geothermal and drilling fluids may contain toxic materials that kill plants and damage the soil's ability to regrow vegetation. Chemical emissions may also be harmful to vegetation, since toxic substances emitted by geothermal power generation, such as mercury can accumulate in soils and plant tissues.

Water Drawdown. Lower water levels at Little Lake due to water drawdown for geothermal and support facilities would cause a change in riparian vegetation. Emergent aquatic plant species such as bullrush (Scirpus olneyi) or cattail (Typha sp.) which presently occur around the lake margin would be reduced or lost as these plants only occur where surface water is present. Rush grasses such as Juncus sp. and Heleocharis sp. (spike rush) and salt grass would become established on the former lake bottom and a marsh would eventually result. A photograph taken in 1913 shows the Little Lake area in this marsh state.

Removal of Vegetation. The most significant impact would come from the removal of vegetation from sites of the power plant complex, drill pads, sumps, reserve pits, access roads and transmission line pylons. A total of approximately 2,260 acres of land could be disturbed if both BLM and NWC programs are fully implemented. The amount of vegetation lost will depend upon the placement of these various facilities, since the amount of plant cover varies greatly in the CGSA. After a drilling pad area is abandoned and ecological succession slowly takes place, it has been estimated that 30 to 40 years are required in the best circumstances and well over 100 years may often be necessary (Vasek, et al., 1975a). Normally, this process involves several different types of plant species. Short-lived pioneer species first appear, followed by a series of longer-lived perennial species (Vasek, et al., 1975a). Weedy non-native species such as Russian thistle often displace the pioneer species and prevent succession.

Crushing of vegetation by vehicles and foot traffic would occur (Davidson and Fox, 1974). Effects of trampling by field crews can be seen many years later (Vasek, et al., 1975).

An important factor in determining what types of plant communities would be affected is the location of the usable geothermal field on the CGSA. Zones 1 and 2 are largely characterized by "Mixed Desert Scrub" (Thorne, 1979).

2.8.2.2 Areas of Sensitivity Within CGSA

Although, overall, the CGSA appears to contain a monotonous array of dry-tolerant plants, dominated by a few species such as Creosotebush, several areas have been found which could be described as sensitive (see Figure 2.8.2-1).

The areas discussed here should be considered in conjunction with sensitive wildlife habitat areas described in Section 2.7.2 and also those soils types mentioned in Section 2.6.2 as being especially vulnerable to compaction and/or to wind and water erosion.

Riparian Vegetation. The riparian vegetation which borders Little Lake and Haiwee Spring comprises two very sensitive areas (see Figure 2.8.2-1) As mentioned in Section 2.7.2, there is a high probability that the water level of Little Lake will be lowered if water utilization for the proposed program reaches projected levels. The marsh area surrounding Little Lake supports numerous riparian plant species, including the CNPS-designated rare cord grass (*Spartina gracilis*). Lowering of Little Lake could cause the local loss of this rare plant, as well as the reduction of other species which can only exist in oases in an otherwise arid environment. Haiwee Spring is not likely to be affected (see Hydrology Technical Report).

Other Sensitive Areas. Red Hill is a sensitive area, near the base of which may be found the rare white canbya (*Canbya candida*); in addition, cinder cones have unusual heat- and moisture-retentive qualities which may have a "hothouse effect" on plants growing there (DeDecker, in County of Inyo, 1979; Appendix O: 19 and R. Weiss, 1979, personal communication).

Coso Hot Springs, a National Register of Historic Places site, is also the only locality in the CGSA in which the rare parasitic plant, *Pholisma* arenarium, is found.

Rocky exposures and areas of thin stony soil are also especially vulnerable; any vegetation disturbed or destroyed in such areas would require many years to recolonize, up to 100 years for some species even if a revegetation plan is implemented (Vasek et al., 1975a).

Areas not shown on Figure 2.7.2-1 or Figure 2.8.2-1, or described as especially vulnerable to compaction or erosion in Section 2.6, may be considered as relatively less sensitive to vegetation damage resulting from the proposed action. This assessment is subject to revision after further site-specific study. In general, it can be stated that vegetation in broad valleys (and on some smaller areas of nearly level terrain) recovers more quickly, once disturbed, than that on steeper slopes. Again, it should be remembered that the entire CGSA, like all desert ecosystems, is a sensitive area where damage to plant life can persist for decades and even up to 100 years, even when a restoration plan is implemented.

2.8.2.3 Rare and Endangered Species and Species of Limited Distribution

Seven plant species of special concern could be impacted by geothermal development.

Spartina gracilis (alkali cord grass). If the level of Little Lake is lowered, this CNPS-listed rare plant could be adversely affected, and could be locally extrapolated.

Pholisma anenarium (pholisma). The population of the CNPS-listed rare species is located in Zone 1, within the NWC free-owned Coso Hot Springs National Register Site, and is so localized that geothermal development, if ever to occur here, would be able to avoid it.

Canbya candida (white canbya poppy). Because canbya is located in a zone of unrated geothermal potential, its habitat may never be proposed for disturbance. If it is disturbed, significance of the loss of this population is moderate.

Four additional species of limited distribution are worthy of monitoring: little gold poppy (Eschscholzia minutiflora); twining snapdragon (Antirrhinum filipes); desert neststraw (Stylocline micropoides); and leather-leaved viguiera (Viguiera reticulata), although they are not likely to be significantly impacted by geothermal development. They are scattered throughout the CGSA, making sensitive habitat identification difficult. The loss of these plants in any one location would be of low significance because they are distributed in other parts of the southern California desert.

2.8.2.4 Impacts During Phases of Geothermal Development

Preliminary Exploration. Impacts would result mainly from off-road vehicle use, and drilling of test wells for heat-flow measurements. Vehicular traffic from this phase would cause compaction and movement of the natural soil surface. Impacts to plants during this stage would be mainly due to trampling of perennials, some soil compaction from vehicles and possibly some wind- or water-induced erosion. The extent of surface disturbance is expected to be as described in Chapter 1; area disturbed in Zones 1 and 2 would be largely Mixed Desert Scrub. In Zones 3 and 4, any of the flora encountered in the CGSA may suffer some damage.

Exploratory Well Drilling. During this stage, major localized disturbances to flora could occur. As discussed in section 2.7.2, an estimated 112.5 acres of Mixed Desert Scrub in Zones 1 and 2 would be removed if 100 exploratory wells are drilled in those zones. No known rare or endangered species would be disturbed, since the immediate vicinity of Coso Hot Springs would not suffer surface disturbance. In Zones 3 and 4, if 300 exploratory wells are drilled, vegetational destruction may amount to 338 acres. This could include any type of common vegetation encountered in the CGSA.

use the # of well pads not wells

Compaction of soils will also occur and, erosion by wind and occasional heavy rains may be increased, which could impoverish the soils, slow revegetation and allow weedy species to invade. During most of the year the CGSA is extremely dry, and dust would be generated from roads and drill pad areas due to vehicular use. The high winds which occur very frequently in the area may result in abrasion of sensitive plant surfaces as soil particles are blown by winds. Small plants may be buried by wind-blown particles.

It is assumed, however, that the preliminary exploration stage would yield sufficient information regarding well locations and flora on selected sites, and that facilities may be located so as to minimize vegetational impacts during this stage.

Field Development. Destruction of the vegetation at the site of the power plant and ancillary facilities is generally total. Some 800-1000 acres may eventually be disturbed; somewhat less than half of this destruction again, may affect any of the species and vegetative associations within the CGSA.

During full field development, all impacts described for the previous stages would be roughly doubled as a result of the greater number of disturbed acres. Increased plant productivity may be noted along the sides of access roads and transmission lines (Vasek, et al., 1975b; see also Section 2.7.2.

Resource Utilization. During operation phase there would be additional disturbances to the habitat. Areas cleared of native vegetation could become colonized by weedy plant species. As the species reproduce, they may spread into 'the disturbed natural plant communities near the power plant complexes. For example, near Victorville where red brome, (Bromus rubens) and other Mediterranean grasses have spread into Creosotebush Scrub and Joshua Tree

Woodland communities (Henrickson, personal communication). The resulting competition from these introduced species may mean a gradual loss of native vegetation, continuing long after construction is completed. If herbicides are used in weed control, these may be washed or blown onto native vegetation, causing additional impact.

During this phase, there is a possible indirect effect of lowering ground water levels near Little Lake. Loss of riparian vegetation would occur along the borders of the lake, and in particular Spartina gracilis, the rare cord grass found at this location, may be reduced or lost.

Since the geothermal fluid has not been completely characterized, estimates of chemical emissions and their impact may be inaccurate. Chapter 1 indicates that condensed steam will be used as make-up water for the cooling tower. Gases such as carbon dioxide and hydrogen sulfide (H_2S) will be emitted, as will the heavy metal mercury. (Since 95 percent of hydrogen sulfide will be scrubbed, the actual emission rate of this toxic gas will be so low that it should not affect plant or animal life.) Water vapor emissions will be accompanied by mercury at an estimated rate of 10×10^{-8} by weight per unit water (see Section 2.2). The amount of water vapor emitted by the cooling tower of a 50-MW power plant is estimated at 1.1×15^5 g/sec. Hence, mercury emissions will be about 95 g Hg per 50-MW power plant per day; and mercury levels in atmospheric air are estimated to be 0.01 ug/m^3 (Technical Reports: Air Quality, Chemical Emissions). Schroeder (1971) considers prolonged exposure to atmospheric levels in excess of 0.1 ug/m^3 to be harmful to humans and mammals in general. Since estimates for the atmospheric levels in the CGSA are one-tenth that amount, no immediate health problem is foreseen.

The hazard to both flora and wildlife from mercury accumulation in soils, as well as plant and animal tissues, during geothermal power development and use has been documented in a few preliminary studies (Siegel and Siegel, 1975; Robertson, et al., 1977; Fang, 1978). Mercury is absorbed by dry soils (Fang, 1978) and can be concentrated in plants at levels from 10 to 20 times higher than soil levels (Siegel, et al., 1973). Field studies have shown that mercury is commonly concentrated 10 to 100 times by soil fungi and in invertebrates such as annelids and millipedes (Siegel and Siegel, 1975). Thus, mercury could possibly accumulate, eventually, to harmful levels in soils, and in plant and animal tissues.

Close-Out. In the close-out stage there would be some increase in habitat disturbances: Power plant units would be removed, wells capped, and sumps and reserve pits returned to natural grade.

2.8.2.5 Cumulative Impacts

Cumulative impacts to vegetation as a result of the proposed action and the NWC development together would be generally as described in Section 2.7.2.5. Surface disturbance in Zones 1 and 2 would affect largely such common associations as Creosotebush and Shadscale Scrub and Mixed Desert Scrub. The likelihood of impact to Pholisma arenarium seems slight unless host vegetation near Coso Hot Springs is further reduced. Elsewhere in Zones 1 and 2, and throughout the rest of the CGSA, the possibility exists for damage to those species whose distribution is limited; this possibility is increased by the development of additional facilities for the NWC. An additional cumulative impact may be lowering of water tables and consequent alteration of aquatic or semiaquatic habitats, which would probably affect the rare cord grass, Spartina gracilis, near Little Lake.

The overall productivity and ecological balance of the CGSA--as a management unit and in relation to its surroundings in the region--would be a matter for ongoing study and care. Displacement and destruction of desert vegetation in its natural physiognomy and structure within this area would leave scars visible for many years.

2.9 VISUAL RESOURCES

2.9.1 Present Visual Setting

2.9.1.1 Landscape Character

All landscapes have a readily identifiable character, regardless of size, location, or land use. Those landscapes that possess or have potential for a greater degree of visual variety are more desirable than those that tend to be monotonous. Each characteristic landscape is determined by the features that are seen and their arrangement in the landscape composition. These landscape features are the landform, vegetation and structures. Each particular feature is defined by the four basic elements of form, line, color and texture. All of the basic elements are present in every landscape, but exert various degrees of visual influence. The more elements that exert a strong visual influence or contrast in the landscape, the stronger or more interesting the landscape character. The degree of variety and harmony among the basic elements determines whether or not a given landscape is pleasant to view.

2.9.1.2 Observer Position

Landscape character is determined by viewing portions of the landscape. The placement and relationship of the viewer to the landscape is the "observer position". From this position the extent or area that can be viewed is normally limited by landform, vegetation, or distance. This is the seen area. Those portions of the landscape which are generally not visible from observer positions, and which are beyond approximately 15 miles are the seldom seen areas. In addition, several variables influence visual perception from these observer positions and determine how well contrasts are seen. These variables are: distance, angle of observation, time, size or scale, season of the year, light, and atmospheric conditions.

As observer positions heavily influence the determination of seen or seldom seen areas these positions are carefully selected to fairly represent the viewed portions of the landscape. One or a series of observer positions on a travel route, such as U.S. 395, or at the use area, such as the National Register Site, become "key observation points," (KOP). Rose Valley has been designated as a scenic corridor by the State of California. In seldom seen areas, the observer positions are those which appear to be "likely observation points."

The basic elements of form, line, color and texture are used to describe the landscape features of the CGSA from five "key or likely" observation points. (See Appendix E)

2.9.1.3 Scenic Quality

The Coso Range. Although two-thirds of the CGSA is of the strong relief of the Coso Range, the scenic quality is of a generally low quality. The complex but sparse vegetation patterns of creosote bush, Joshua Tree and mixed desert scrub are generally insignificant. Numerous intrusions are in evidence on all of the landforms. Graded roads, range targets and testing facilities are instrusions in the HIGH GRANTIC RIDGES AND SLIDE SLOPES. Mining activity with the associated pipes and structures in the Devil's Kitchen area, and the weathered wood and stone buildings of the resort area are intrusions upon the ENCLOSED BASINS. The hot springs of this desert area is a relative water feature. Another notable feature is the localized color found in the soils of the Devil's Kitchen area. The RHYOLITE DOME FIELD includes Sugarloaf Mountain and is a notable feature (Figure 2.9.1-1). The obsidian and pumice deposits in the rubble land flanks of these upland cinder cones are visually interesting.

Rose Valley Plain. One-third of the CGSA is a broad valley in which the overall visual effect is common to the desert region, with little visual diversity. The vegetation is sparse with little variety to the broad expanse of mixed desert shrubs. The area is heavily intruded with numerous unimproved road, the Gil Station highway rest stop, U.S. 395, transmission corridors, mines and fences, cultivated fields and agricultural buildings. The ALLUVIAL FANS are the most visible areas of the valley. The LOWER VALLEY FLOOR is expansive but not easily viewed in its entirety due to the depressions, sinks, interplaya dunes and flats (Figure 2.9.1-2). The scenic quality is enhanced by the adjacent scenery of the Sierra Nevada Range to the west and the Coso Range to the east.

Lava Flows. The visual quality is generally strong despite being hevily intruded by U.S. 395, transmission corridor roads and towers, pit mining and access roads. Although there is little or no variety in vegetation, the ground plane is of strong visual interest due to the dark LAVA FLOWS (Figure 2.9.1-3). A notable feature of this landform is the Fossil Falls where the basalt flow assumes configurations, textures and scale unique to the area. The upland basalt flows rise from the valley as a mantle cresting over a portion of the Coso Range. Red Hill, a basaltic cinder cone, is a notable landform with mass and configuration unique to the area.

Fig. 2.9.1-1 ENCLOSED BASIN AND RHYOLITE DOMEFIELD

LANDFORM The massive, symmetrical domes dominate the open basins. Steeply rounded flanks converge on the basin floor in a series of powerful undulations which race down one slope to return up to the crest of another. This uninterrupted flowing of lines is characteristic of this landscape. Darker hued reddish browns continue the undulating pattern at the greyish basin edge. The uniformity of the stones and boulders of the rubble land is a notable large scale fine texture.

VEGETATION The sparse, clumping vegetation is open with minimal form. Notable random and jagged patterns occur on the steep slopes. The grey-green coloration and fine, tufted texture bring unity to the landscape.

CULTURAL MODIFICATION Road grading in the basins and cuts and fills on the slopes are minor forms. These modifications become notable where texture and color have been interrupted, and where these interruptions take on strong linear characteristics not consistent with the undulating line quality.

Fig. 2.9.1-2 BROAD VALLEY PLAIN AND ALLUVIAL FANS

LANDFORM The expanding space of the valley floor is flat, with a notable absence of protruding form. At the base of the massive domes and cinder cones along the perimeter of the valley a strong horizontal line emerges. The undulating and complexly furrowed lines of the distant ridgeline are strong compliments to the heavy horizontal lines of the plain. The grey and tan colorations and smooth, rounded textures unify the scene and provide little variety.

VEGETATION The low, open clumping vegetation has minimal form and spreads as a veneer over the valley floor. Faint linear aspects are apparent where the vegetation is interrupted by striations of denuded transmission corridors, and where it has adopted to depressed playas and raised terraces with variations in color and texture. The ochre, grey-green and olive coloration of the fine, tufted texture is uniform with minimal variety.

CULTURAL MODIFICATION Angular steel towers are noticeable although their open fabrication gives their form a semi-transparent quality The faint linear tracery grey color and metal texture are insignificant at this scale.

Fig. 2.9.1-3 LAVA FLOW

LANDFORM The broad void of the valley floor is interrupted by rugged lava flow silhouettes. The overall line quality is irregular, jagged and horizontal. The most striking element is the coloration of the black-brown basalt flow and the red-brown of the cinder cones, which is strong contrast to the mottled greys and tans of the distant ridgeline. The coarse even texture of the lava flow is quite distinct from the roundly furrowed, soft ridgeline texture.

VEGETATION The low, open clumping vegetation has minimal form, and appears like a veneer on the valley floor. The floor is covered by a broad mosaic of irregular bands and distant striations. Although the ochre and grey-green coloration is typical of the area, it contrasts strikingly with the dark basalt colors in this locale.

CULTURAL MODIFICATION Angular steel towers, spaced at regular intervals, are noticeable although their open fabrication gives their form a semi-transparent quality. These towers and sagging connection wires are faint horizontal and vertical line tracings. The grey color and metal texture are insignificant on this scale.

2.9.1.4 Visual Resources Inventory

The visual resources of the CGSA were inventoried and evaluated by a system which identifies scenic quality and sets minimum quality standards for management of these resources. This system depends upon three factors:

1. The inherent quality of the scenery being viewed.

2. The visual sensitivity, expressing viewer attitudes toward change and volume of use, of the scenery being viewed.

3. The distance zones representing perception levels by which the scenery is being used.

These factors are used to classify all lands into one of five Visual Resource Management (VRM) classes. Each of these classes contains a specific management objective for maintaining or enhancing visual resource values.

See Appendix E for a description of the complete methodology utilized for evaluation of the CGSA.

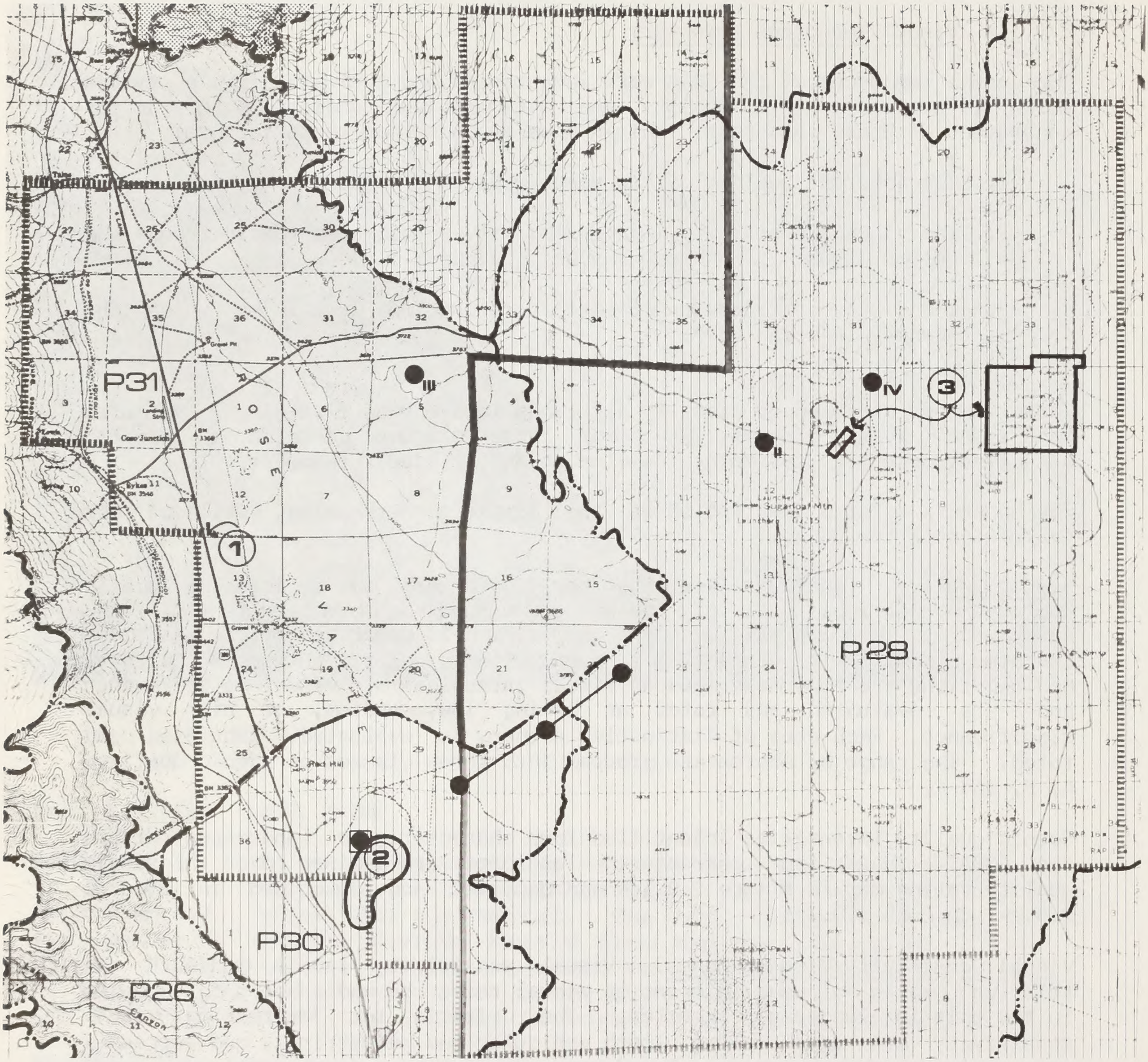
Scenic Quality. Landforms are the key indicators in delineating scenic quality boundaries. All of the scenery within each boundary is all of the same nature. This overall landscape composition is described by the landscape features and their elements of form, line, color, texture. Cultural modifications are also described as visual intrusions or visual improvements and are evaluated and rated as having low, medium, or high visual significance. Each area of distinctive scenery is evaluated, tabulated and rated. The range of scores are grouped into three classes of scenic quality: A, B, and C.

Scenic quality inventories indentified four characteristic landscapes within the CGSA. These four characteric landscapes are delineated on the scenic quality rating map in Figure 2.9.1-4 and depicted and described in Figures 2.9.1-1 through 2.9.1-3.

Visual Sensitivity/Visual Zones. Visual sensitivity levels indicate the relative degree of user interest in visual resources and concern for changes in the existing landscape character. The criteria for determining visual sensitivity are user volume (both vehicular and pedestrian), and expressed user attitudes toward change. Based upon user volume and user attitude toward change the areas within view of US 395 and the two National Register sites were determined to be highly sensitive to modification.

Distance zones are determined in the field by actually traveling each route and observing the area that can be viewed. The zones are delineated by the following criteria.

Foreground-Middleground Zone. The area seen from a distance of three



KEY OBSERVATION POINTS

1. US 395
2. FOSSIL FALLS
3. COSO HOT SPRINGS NATIONAL REGISTER SITES

SCENIC QUALITY RATINGS

= A

= B

= C

Fig. 2.9.1-4

to five miles where activities may be viewed in detail. The outer boundary of this zone is defined as the point where the texture and form of individual plants is not longer apparent in the landscape.

Background Zone. This is the remaining area which can be seen from each travel route to approximately 15 miles. Vegetation should be visible at least as patterns of light and dark.

Seldom Seen Zone. These lands are identified as unseen or beyond the approximate 15-mile limit from key observation points.

Visual Resources Management Classes. Visual resources management classes are management objectives which describe the degree of modification allowed in the basic elements of the landscape. The primary character of the landscape should be retained regardless of the degree of modification.

The following is a description of the five VRM class objectives::

Class I. This class provides primarily for natural ecological changes only. It is applied to designated primitive areas, some natural areas, and other similar situations where management activities are to be restricted.

Class II. Changes in any of the basic elements (form, line, color or texture) caused by a management activity should not be evident in the characteristic landscape.

Class III. Changes in the basic elements (form, line, color and texture) caused by a managment activity may be evident in the characteristic landscape. However, the changes should remain subordinate to the visual strength of the existing character.

Class IV. Changes may subordinate the original composition and character but will reflect some basic elements of the character type.

Class V. Change is needed. This class applies to areas where the natural character has been disturbed to the point where rehabilitation is needed to bring it back into character with the surrounding countryside. This class would apply to areas identified in the scenery evaluation where the quality class has been reduced because of unacceptable intrusions. It should be considered an interim, short-term classification until one of the other objectives can be reached through rehabilitation or enhancement. The desired visual quality objective should be identified.

The determination of the visual resources management class and therefore the visual sesources management objective for a particular area is based upon consideraton of the various combinations of the three inventory variables, i.e. scenic quality, visual sensitivity, and distance zones. Table 2.9.1-1 shows the matrix used in considering these variables to determine the management class. The lands within the CGSA fall within VRM classes II, III,

Table 2.9.1-1

Visual Resource Management Matrix

VISUAL SENSITIVITY LEVEL

		HIGH			MEDIUM			LOW		
SPECIAL AREAS		I	I	I	I	I	I	I	I	I
	A	II	II	II	II	II	II	II	II	II
SCENIC	B	II	III	IV	III	III	IV	III	IV	IV
CLASS	C	III	IV	IV	IV	IV	IV	IV	I	IV
		FG	BG	SS	FG	BG	SS	FG	BG	SS

DISTANCE ZONES

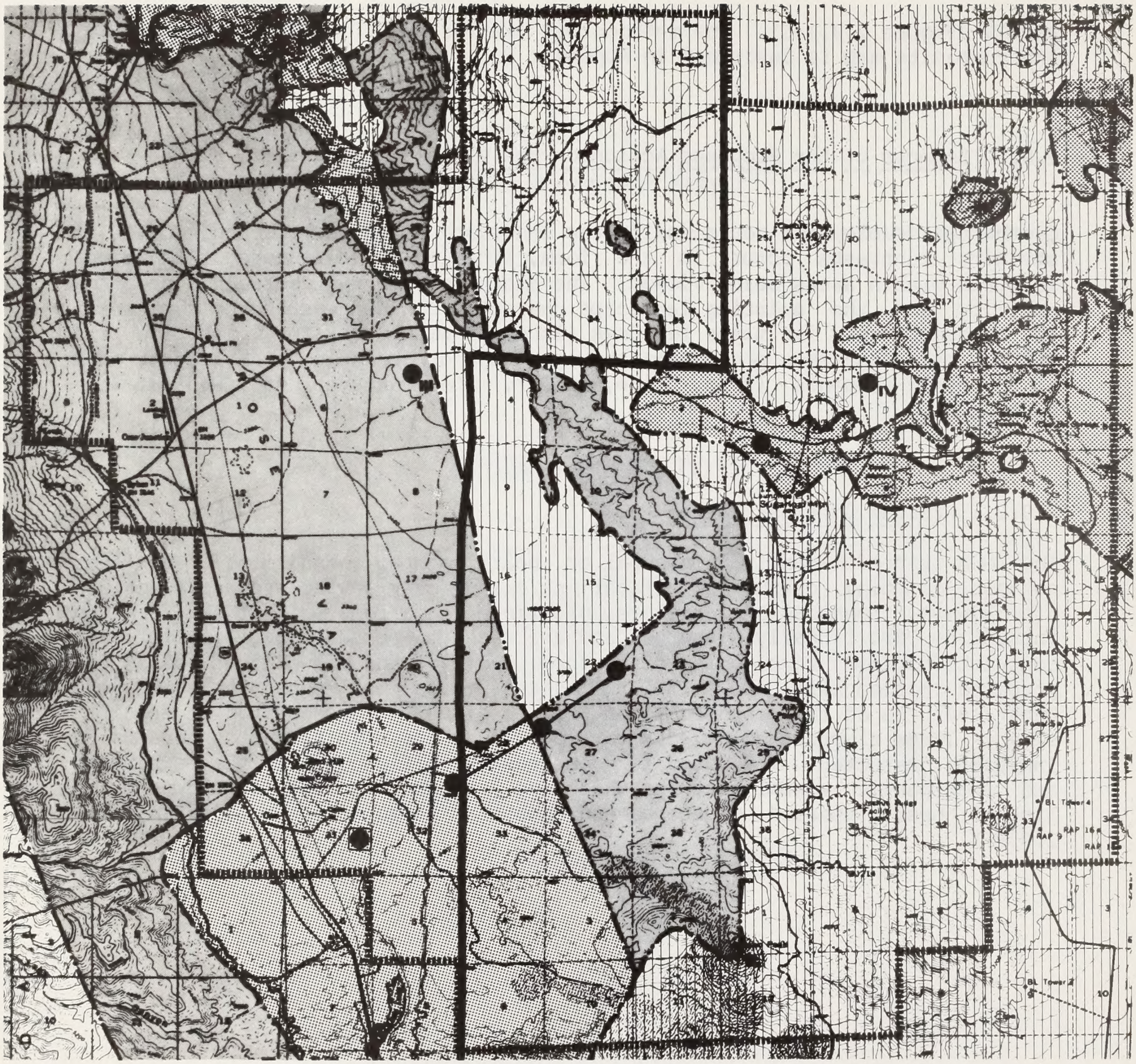
and IV (Figure 2.9.1-5). The methodology use for compiling the data base into the composite map is described in Appendix E.

2.9.2 Impacts of the Proposed Action on the Visual Setting

Geothermal development could modify the landscape character of the CGSA if striking contrasts occur in the form, line, color or texture of landscape features within areas being viewed. The amount of contrast between a proposed activity and the existing landscape character can be measured by separating the landscape into its major features (land and water surface, vegetation and structures), and then predicting the magnitude of change in constrast of each of the basic elements (form, line, color, and texture) to each of the features.

2.9.2.1 Visual Contrast Rating

The CGSA is predominantly in natural or near natural condition. The most notable existing cultural modifications extend over a wide area as a network of roadways, transmission corridors, pipelines and fencing. These lengthy intrusions are lineally dispersed and are rated to be realtively insignficant contrasts to form, line, color or texture. Some of the viewed features of the proposed action will be similarly dispersed and will expand this network. Other features of the proposed acton will be visually concentrated at specific sites. These clusters of development could engender significant constrasts to landscape character. Not rated for constrast significance are the ephemeral and atmospheric visual features which are attendant to field development. A list of these dispersed, clustered and ephemeral features is provided in Table 2.9.2-1.



VISUAL RESOURCE MANAGEMENT CLASSES

= CLASS II

= CLASS III

= CLASS IV

Fig. 2.9.1-5

TABLE 2.9.2-1

Dispersed Features of Development

1. Temporary roads
2. Access and maintenance roads
3. Improved roads
4. Water pipelines
5. Insulated steam lines with expansion loops
6. Transmission towers and lines

Clustered Features of Development

1. Graded pads
2. Sumps and pits
3. Drilling rigs
4. Well heads
5. Cooling towers
6. Turbine generation plant
7. Substation
8. Peripheral scarification
9. Parking and martialing areas

Ephemeral Features of Development
(not rated for contrast)

1. Vehicular movement
2. Dust, Steam and Exhaust
3. Lighting
4. Steam

These visual features of development are contrasted and rated in Appendix E worksheets. This contrast rating reveals the elements and features that would cause the greatest visual impact. Those elements with the highest degree of contrast are the ones that can be most easily identified. Most difficult to identify are the development features which are dispersed over an area. The development features which are most easily identified are those which could be clustered on a site. The contrast rating indicates the significance or insignificance of the visual impacts of geothermal development.

2.9.2.2 Insignificant Impacts

The contrast rating reveals that geothermal development would not significantly affect all three landscape features to the same degree. Due to the variable factors of distance and relative scale, the impact upon the form, line, color or texture of LANDFORM would be insignificant. The extent of change to the existing landforms caused by all grading activity would not significantly affect the major elements of form and line; however, minor affects would be visible in changes in color and texture.

More significant would be the impacts of scarification of VEGETATION which would notably interrupt line, color and texture, while form would remain nearly unchanged. Significant contrasts would be found in the basic elements of STRUCTURES.

2.9.2.3 Significant Impacts

Striking differences in form and line would occur with the introduction of geothermal development STRUCTURES. To a slightly lesser degree, color and texture would also be affected. The contrast in all the basic elements would most notably occur as follows:

> FORM - Mass and angular shadows would appear on the floor of basins and valleys where they had not previously occurred. The variable factors of distance, relative scale, period of observation, and light would all diffuse or accent this contrast throughout the daylight cycle.
>
> LINE - Horizontal lines typical of basins and valley floors would be interrupted or made discontinuous altogether. Conversely, much of the intermittent line quality would be overlaid with long, unrelieved linear networks and corridors extending entirely across the area being viewed.
>
> COLOR - Contrasts in color would occur as flecks of contrast interrupting the existing mosaic. In some cases, brightly hued colors would be quite assertive.

TEXTURE - Contrasts in texture would be the least noticeable of the elements, as relative scale prevents surface texture of structure from becoming visually significant. Interruptions in existing patterns and mosaics would be of significance.

2.9.2.4 Simulation of Impacts

Since the location and description of this project is not well defined five situations which were considered to be "typical" for each of the landscape character types were chosen for purpose of impact analysis and evaluated from the most critical location under the most critical viewing conditions. Figures 2.9.2-1 through 2.9.2-5 are visual simulations of these five situations. These evaluations assume full development which would be the worst case and most long term situation. The geothermal development features which are illustrated are a power generating, site a transmission corridor and an electrical substation.

Fig. 2.9.2-1 TRANSMISSION CORRIDOR SIMULATION

VRM CLASS IV REQUIREMENTS: Contrasts may attract attention and be a dominant feature of the landscape. The change should repeat the basic elements inherent in the characteristic landscape.

CONTRAST RATING: The contrast can be seen, but does not attract attention. The level of contrasts is acceptable.

FORM: No impacts upon landform, vegetation or structures.

LINE: Denudation of service roads would weakly impact vegetation by interrupting striations.

COLOR: Scarification of service road corridor would weakly impact landform and vegetation by creating flecks of grey-white on the landscape.

TEXTURE: No impacts upon landform, vegetation or structures.

Fig. 2.9.2-2 POWER SUBSTATION SIMULATION

VRM CLASS II REQUIREMENTS:	A contrast may be seen but should not attract attention. Changes in any of the basic elements should not be evident in the characteristic landscape.
CONTRAST RATING:	The contrast begins to dominate the characteristic landscape and attracts attention. The level of contrasts is unacceptable.
FORM:	Earthwork will weakly impact the existing landforms and vegetation as the essential character will remain flat. A cubicle structure will moderately impact an area where form has been notably absent previously.
LINE:	Horizontal angularity of ground plane will be weakly impacted. Rigid, rectilinear structures and softly parabolic power lines will be new additions to landscape character with weak impacts.
COLOR:	Earthwork will cause moderate impacts of grey to white on the basalt, brown lava covered surface.
TEXTURE:	Textural contrasts will be weak impacts on landform, vegetation and structures.

Fig. 2.9.2-3 POWER GENERATING SITE SIMULATION

VRM CLASS III REQUIREMENTS:	Contrasts to the basic elements may be evident and begin to attract attention in the characteristic landscape. However, the changes should remain subordinate to the existing characteristic landscape.
CONTRAST RATING:	The contrast begins to dominate the characteristic landscape and attracts attention. The level of contrasts is unacceptable.
FORM:	Earthwork will be flattened with weak impact on landform. The long, rectilinear shell and towers will moderately impact on area previously devoid of form.
LINE:	The rectilinear and parabolic silhouette of structures will moderately impact an area which previously had been notable for the lack of such lines.
COLOR:	The grey to white of the concrete and metal structure will moderately impact the site.
TEXTURE:	Earthwork will weakly impact landform and vegetation patterns. The smooth to metallic texture of structures will be weak impacts.

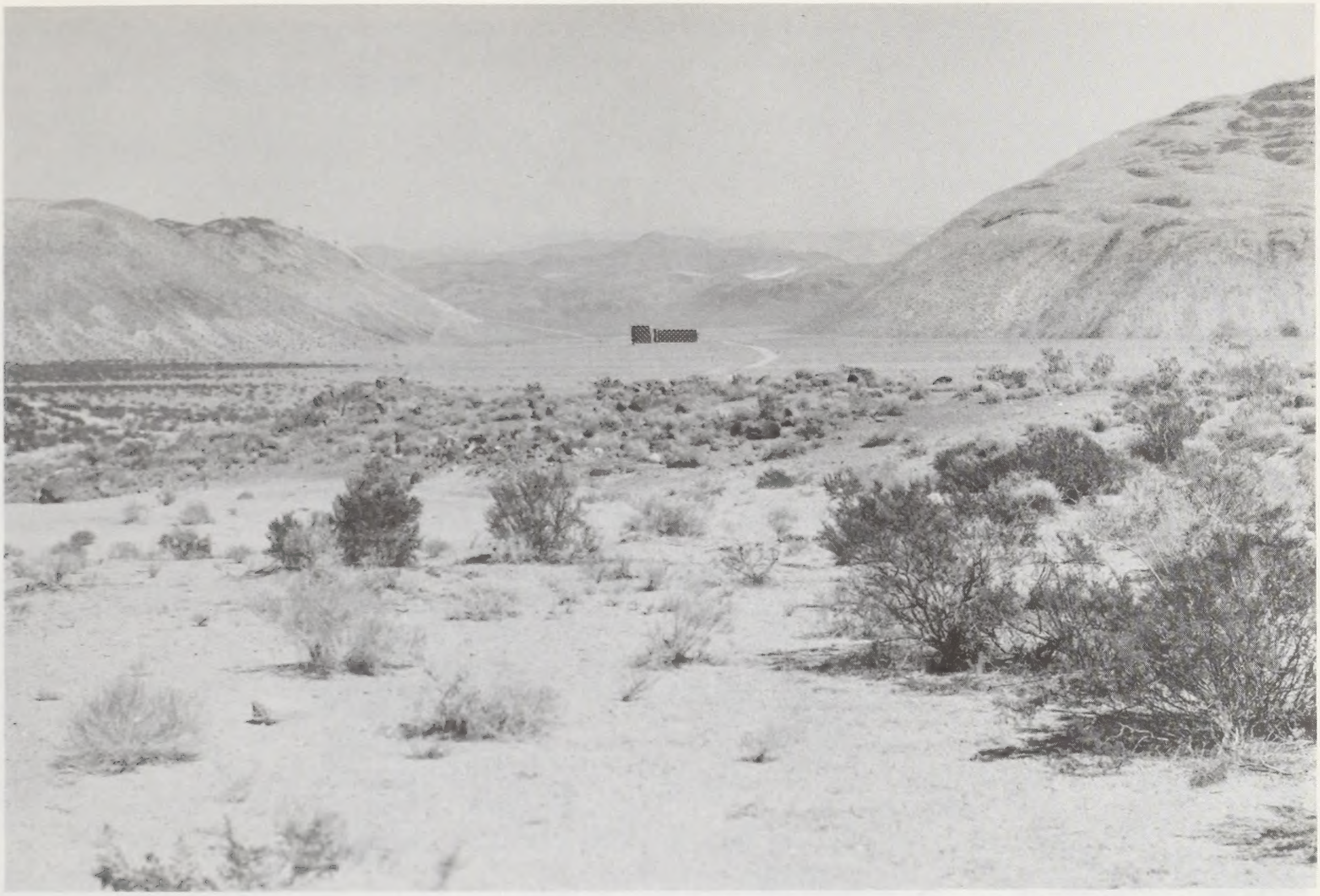


Fig. 2.9.2-4 POWER GENERATING SITE SIMULATION

VRM CLASS II REQUIREMENTS: A contrast may be seen but should not attract attention. Changes in any of the basic elements should not be evident in the characteristic landscape.

CONTRAST RATING: The contrast begins to dominate the characteristic landscape and attracts attention. The level of contrast is unacceptable.

FORM: Earthwork will be flattened and will weakly impact landform and vegetation. The massive, cubicle and horizontal structure with rounded verticals will strongly impact an area previously notable for an absence of such form.

LINE: The parabolic and rectilinear silhouette of the structure is a moderate impact with line characteristics new to the area.

COLOR: The bright grey to white of the metallic and concrete structures are moderate contrasts.

TEXTURE: Earthwork and denudation will cause the texture of landform and vegetation to be uneven. The structure will be smooth to metallic. These impacts are insignificant.

Fig. 2.9.2-5 POWER GENERATING SITE SIMULATION

VRM CLASS IV REQUIREMENTS: Contrasts may attract attention and be a dominant feature of the landscape. The change should repeat the basic elements inherent in the characteristic landscape.

CONTRAST RATING: The contrast will not be overlooked and demands attention. The level of contrast is acceptable.

FORM: Landform will be flattened and mounded with moderate impacts. The long, rectilinear shell of the power plant will strongly impact the site.

LINE: The angular, discontinuous line of earthwork on the landform and the parabolic to rectilinear line of the structure will moderately impact the site.

COLOR: Scarification, denudation and new concrete and metal structures moderately impact the site with grey to white.

TEXTURE: Scarification will cause landform and vegetation to be more uneven. Structure texture will be smooth and metallic.

2.10 CULTURAL RESOURCES

2.10.1 Present Cultural Resources Setting

This section summarizes what is known of the prehistory of the study area (the CGSA) and the ethnography of the peoples inhabiting the region at the time of European contact. The history of the area since 1860, when Anglo-American mining and settlement began, is briefly sketched. The methodology and results of an archaeological survey of approximately 29 percent of the CGSA are summarized, and the overall significance of the findings is discussed; a full discussion of methodology and results is presented in the Cultural Resources Technical Report.

2.10.1.1 Prehistory

Man's use of the region began during the Paleo-Indian period (or more than 10,000 years ago) when aboriginal hunters trapped and killed the now-extinct large Pleistocene mammals along lake beds and in box canyons. No direct evidence for Paleo-Indian use of the CGSA, per se, has been found, but evidence at nearby China Lake suggests that these wide-ranging hunters regularly traversed this area (Davis, 1975).

Evidence of human use of the CGSA vicinity has been found at Fossil Falls, at the southwestern corner of the CGSA, and may date to 10,000 before the present (Harrington, 1952). A hunting and gathering subsistence pattern had evolved, focused on the utilization of stream and lakeshore plant resources and the hunting of large game animals. This period corresponds to what is known as the Western Lakes Pluvial Tradition, a period in which much of California and the Great Basin was characterized by lakes resulting from the run-off from glaciers, and by the generally wet climatic conditions at the end of the Pleistocene Period. These early environmental conditions provided a habitat that was very favorable in terms of human occupation.

Judging from the work of numerous researchers in this area, aboriginal use of the region appears to have been continuous from this period until the arrival of Anglo-Americans in the 19th century (e.g. Harrington, 1957; Lanning, 1963). However, the intensity of use of the area very probably changed as the environment shifted toward the arid regime now characterizing the CGSA; this aridity is emphasized by the rain shadow cast by the Sierra Nevadas. Archaeological evidence from the region, in general, indicates an increasing emphasis on the exploitation of plant resources other than those associated with streams and lakeshores. Specifically, pinyon trees were of increasing importance throughout the aboriginal occupation of the area (c.f. Bettinger, 1976). While no pinyon forests are presently found within the CGSA, there is a possibility that these were prehistorically present. Other plant communities now found in the CGSA consist of those that were also exploited during the seasonal plant-gathering rounds of the prehistoric population; numerous bedrock grinding slicks indicate that grasses and seeds were gathered and processed in the CGSA.

While opinions of researchers vary, some believe that at some point during the prehistory of the CGSA, the Coso Range may have at some time functioned as the focus of what has been interpreted as a hunting cult, which appeared to emphasize the exploitation of bighorn sheep and which probably was at its apex between 3000 and 1000 B.C. (Grant, Baird and Pringle, 1968). During this period the bow and arrow were introduced, replacing the less accurate throwing board, or atlatl, and dart. The remnants of the hunting magic apparently associated with this cult are the numerous rock art sites, characterized by petroglyphs, or pecked designs, of bighorn sheep and hunters, covering the basalt walls of canyons. While the majority of the known rock art sites are located within the Coso Range to the east of the CGSA, the discovery of isolated petroglyphs and one canyon with considerable rock art in the distinctive Coso style within the study area indicates that portions of the project region were used for the hunting of bighorn sheep. The sites of these petroglyphs may have been sacred; that is, the locations of ceremonial activities relating to the preparation for the hunt. Grant, Baird and Pringle (_ibid._) have hypothesized that the introduction of the bow and arrow increased the hunters' efficiency to the point that they over-exploited the bighorn sheep; both the herds of sheep and the hunting cult consequently died out.

Another important factor in the prehistory of the CGSA is the existence of a major obsidian source at Sugarloaf Mountain. Obsidian was the primary (and preferred) material for aboriginal stone tools made in this general region. The obsidian from this location was used in the manufacture of all types of stone tools and implements by various aboriginal groups. Studies on the existence of Coso obsidian in neighboring areas such as Rose Springs and Little Lake indicate that it appears to have been utilized throughout the prehistory of the region, though it is not known at what point this natural resource was first used (Clewlow _et al._, 1970). Evidently the resource was not claimed exclusively by the immediate inhabitants of the CGSA; rather, the area seems to have been regarded as a "free zone," where peoples from other areas could mine the obsidian as needed. This contributed to an unusual amount of prehistoric traffic into the area. One pictograph (or painted rock art site) within the CGSA appears, on the basis of artistic style, to have been painted by a group from another region. It can be hypothesized that this ceremonial spot, with an associated camp, represents the remains of regular visits to the Coso area by Indians from other areas for the express purpose of exploiting the obsidian resource at Sugarloaf Mountain.

2.10.1.2 Ethnography

The ethnographic period is that period, after the arrival of white settlers, during which the aboriginal inhabitants followed, to some degree, their traditional lifeways. During this period, the general region of the CGSA and Owens Valley was studied by the anthropologist Julian Steward (1933; 1938). Steward stated that the study area was inhabited by the Koso or Panamint Shoshone-speaking peoples. Some portions of the CGSA, were within the Kuhwiji district, a large subsistence area. That is, finding the resources needed for the inhabitants' subsistence required that they move seasonally throughout a large area which may have included Saline Valley, Owens Lake, the Sierra Nevada and even Death Valley. The vicinity of the CGSA was a unit within that area which was used during the periods of the year when its resources were most abundant; for example, rabbits in winter, and the greens at Haiwee Spring in April. Steward indicates that four major villages were located in the Coso region: at Little Lake, Coso Hot Springs, Cold Springs (five miles south of Darwin), and Olancha (Steward, 1938).

In addition to the use of the CGSA for habitation (at Coso Hot Springs and Little Lake), for ceremonial activities (at rock art sites), for obsidian quarrying (Sugarloaf Mountain) and other seasonal hunting and gathering activities, Coso Hot Springs was apparently the site of aboriginal medicinal and ceremonial rituals at the time of the arrival of white inhabitants in the area. The religious use of the Coso Hot Springs by local Native Americans has continued to the present; the background and significance of this site have been outlined by Theodoratus and Smith-Madsen (1977a). See also Section 2.12 of this ES.

To summarize the aboriginal prehistory and history of this area, then, it can be stated that the CGSA is characterized by a basic archaeological record analogous to that found throughout the Great Basin. That is, there is evidence of a continuous but changing aboriginal habitation and utilization of the region starting at least by 12,000 B.C. and continuing into the historic period. However, natural and cultural factors within the CGSA, specifically, combine to produce unique archaeological conditions. Sugarloaf Mountain, a major source of obsidian, may have been the impetus for obsidian quarrying and appears to have resulted in an unusual intensity of activity and trade in the area. The discovery of rock art sites within the CGSA indicates the probable existence of hunting cults and ceremonial spots. Finally, it is conjectured that Coso Hot Springs was apparently known and utilized as a medicinal and ceremonial focus for the aboriginal inhabitants of the region (Theodoratus and Smith-Madsen, 1977).

2.10.1.3 Historic Period

The Anglo-American exploitation of the area did not begin until 1860 when Dr. Darwin French made the first major mining discovery in the Coso Mountains. Prior to this time, European interest in the area had been limited largely to occasional penetrations by trappers, prospectors and settlers. Gold and silver mining activities were concentrated around Coso Village, 11 miles northeast of Coso Hot Springs, during the 1860s. When these ore bodies were depleted, the mining focus shifted to other locales, although mining continued at a reduced level into the 20th Century. During World War I sulfur was mined in the Devils' Kitchen area and cinnabar mining began in the 1920s. Some mining continues today within the CGSA, but outside the Naval Weapons Center.

The commercial development of the Coso Hot Springs has been the subject of considerable research and has been reported on by the Iroquois Research Institute (1979). The area of the main springs was patented in 1905, but development of the resort did not begin until circa 1909 (ibid.). The use of the area continued, with minimal commercial success, until the acquisition of the property by the Navy in 1943. The Site is now listed in the National Register of Historic Places and includes historic, prehistoric and present Native American values.

2.10.1.4 Cultural Resources Inventory

A cultural resources inventory of the CGSA was performed in the winter of 1978-1979. For the first stage of the survey, approximately 10 percent of the CGSA was inspected using stratified random sampling (see Glossary). For this purpose, the CGSA was divided into five areas of approximately equal size. Ten sample units, each, were randomly chosen in three of these areas and all major environmental zones were assured of being sampled. Environmental zones within the CGSA were identifed as terraces, valleys, playa lakes (see Glossary), mountain areas with intermittent stream courses (identified by observation and from USGS 15-minute topographic maps) and mountain areas with such observable stream courses. The 50 sample units consisted of squares 1/2 mile by 1/2 mile (1/4 square mile in area). Six four-person crews were used. Each unit was visually inspected by walking a series of transects across the unit, with crew members spaced 20 to 30 meters apart, in accordance with BLM inventory standards.

At the conclusion of the first sampling stage, results were tabulated and the sample units for the second stage were apportioned. In this stage emphasis was placed on Geothermal Zones 1 and 2; in addition all remaining units in the terrace and playa lake environmental zones were sampled, as well as several within the noncompetitive lease area. The remaining units required for a 25 percent sampling were distributed within mountain areas containing stream courses. Since time permitted, and it was felt more balanced sampling could result, additional units in eastern Rose Valley were also sampled. Slightly more than 15 percent of the CGSA was sampled in the second stage; the total for both stages was approximately 29 percent. In both stages, if a site was encountered by a team while walking across terrain not selected for sampling, or if a site extended beyond the boundaries of a selected sample unit, such site boundaries were determined and recorded to the extent possible.

Table 2.10.1-1 summarizes the results of both stages of the survey, indicating the number of sites of each type found per environmental zone (see also Figures 2.10.1-1 and 2.10.1-2). These site types are identified in standard BLM usage as shown below:

Archeological Site Types

Lithic Scatter-A site usually consisting of flakes, cores, utilized flakes and flaked stone tools; other cultural material is absent. Study findings were classified as large scatters (greater than 50 m^2), small (less than 50 m^2), heavy or high-density (more than 30 flakes or flake stone tools/10 m^2), and light or low-density (less than 30/ 10 m^2).

Quarry-A site where lithic material has been extracted from a seam, vein or outcrop. The by-products of tool manufacture, including flakes, cores and unfinished tools are found at quarries.

Cemetery-A location where evidence of human interment is found.

Rock Alignment-Lines or more complex arrangements of cobbles and boulders, sometimes representing hunting blinds.

Petroglyph-A site consisting of pecked figures and/or designs on a boulder, rock outcrop, or shelter wall.

Pictograph-A painted figure or design on a boulder, rock outcrop, or shelter wall; petroglyphs and pictographs are frequently discussed together as "rock art".

Isolated Find-An occurence of a single artifact or feature which is not included in another site type.

Cairn-A mound of cobbles or boulders that appear to have cultural significance.

Milling Station-A site indicating the procurement and/or procesing of seeds and other food items; portable milling tools and/or bedrock milling features may be present.

Temporary Camp-A site that was occupied for a short period of time by a few people. Such an occupation would occur periodically over several hundred years.

Utilized Shelter or Cave-Archaeological material (other than rock art) in a rock shelter or cave, or under a rock underhang.

Village-An occupation site that was utilized for a long period of time, generally on a year-round basis. Such a site is distinguished from a temporary camp by the presence of a wider range and larger quantity of artifacts, occupational debris, and usually a midden.

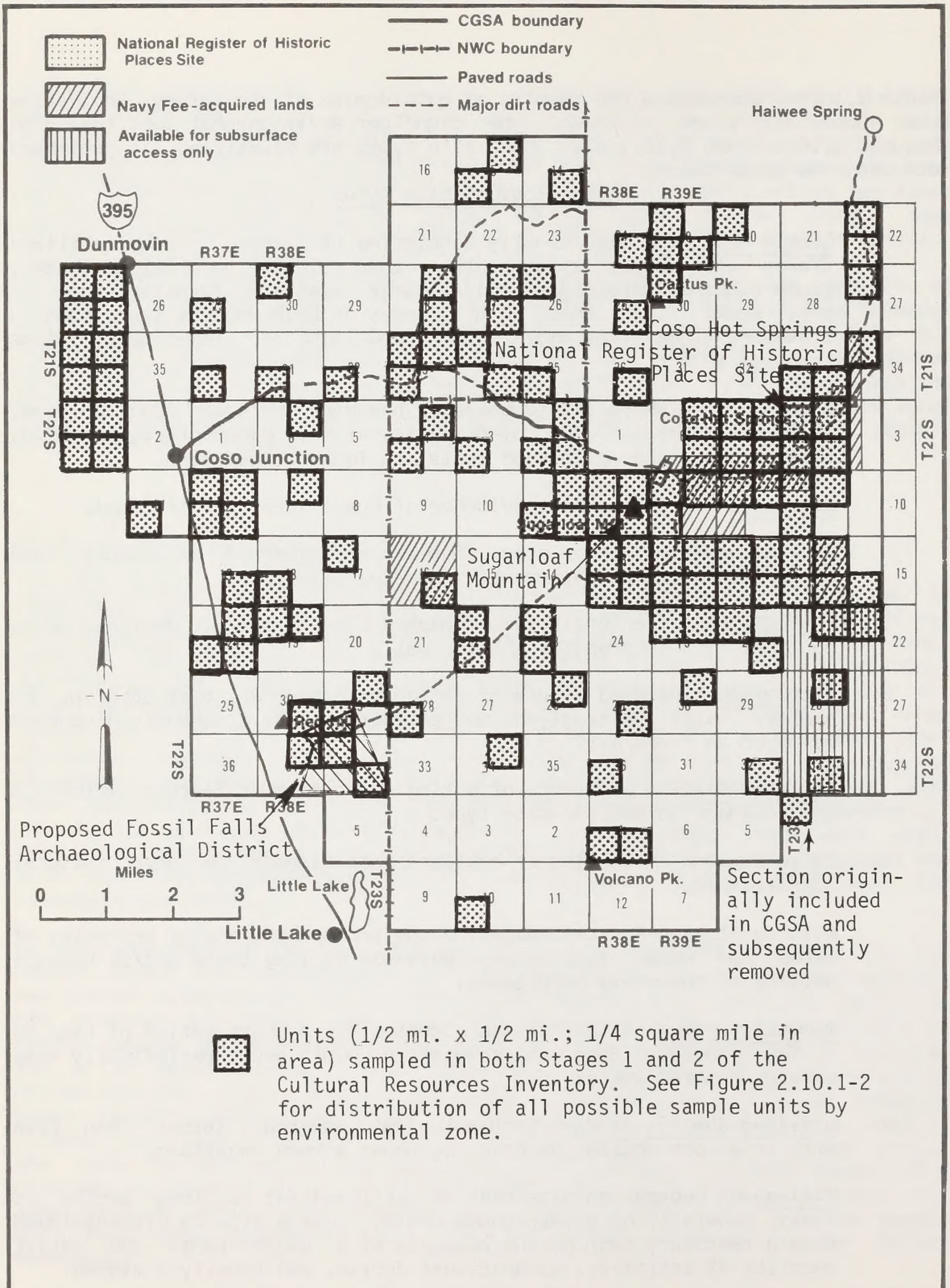


Figure 2.10.1-1. DISTRIBUTION OF CULTURAL RESOURCE INVENTORY UNITS ACTUALLY SAMPLED WITHIN CGSA

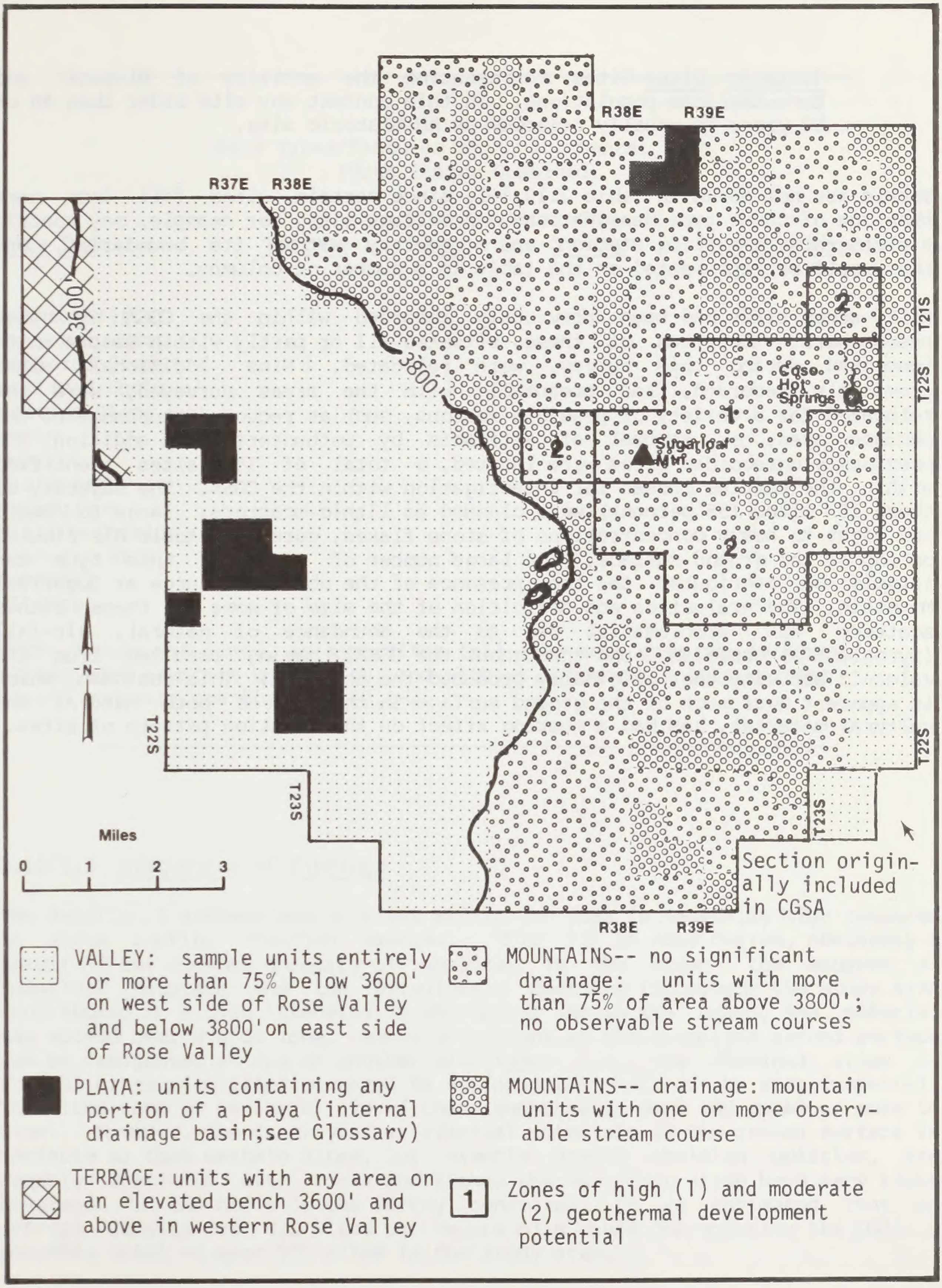


Figure 2.10.1-2. DISTRIBUTION OF ALL POSSIBLE CULTURAL RESOURCE INVENTORY SAMPLE UNITS BY ENVIRONMENTAL ZONE

Historic Sites-Sites representing the activity of Hispanic and Euro-American populations. In this context any site older than 40 or 50 years is usually regarded as an historic site.

Totals are not shown in Table 2.10.1-1, since certain sites fall into more than one of these type designations. A village site, for example, may contain a pictograph, a milling station, and a cemetery within its boundaries, and thus would be represented on the table in a number of columns.

Fifty-seven sites had been previously recorded within the CGSA by other researchers. Fourteen of these, situated all or partly within sample units inspected during this survey, were relocated. Nine additional sites previously recorded, and presumably with the areas surveyed, were not relocated for a variety of possible reasons, such as recent disturbance of the surface area, or removal of artifacts by pothunters. In addition, 139 previously unrecorded sites were located, a total of 153 sites identified within the samples chosen for investigation within the CGSA. The majority of these 153 sites (55 percent) were classed as lithic scatters: large to small and light to heavy concentrations of stone flakes, cores and tools distributed on top of the ground surface. The large number of sites of this type can largely be attributed to the presence of the obsidian source at Sugarloaf Mountain. The evaluation and definition of the size of some of these lithic scatters was problematial due to the abundance of natural, air-fall (pyroclastic) obsidian found throughout the CGSA, having resulted from the volcanic activity that originally produced the obsidian. This obsidian, which is apparent over much of the ground surface in the form of both natural and cultural material, has had a masking effect on the location pattern of sites.

TABLE 2.10.1-1
Site Types/Features by Environmental Zone
(Both Stages Combined)

Site Type	Terrace	Environmental Zone Playa	Valley	Mountain(2)
Lithic Scatter	5	11	13	55
Temporary Camp		5	5	26
Isolated Find	4			6
Utilized Shelter		3		2
Hunting Blind				2
Cairn			1	1
Quarry			1	1
Pictograph				1
Petroglyph	1			2
Milling Station				1
Historic Site		1		7
Cemetery	1			1
Village	1			2

NOTE: Totals not given, as some sites fall into more than one category.
(2) Includes mountain units with, and without, observable intermittent stream courses; see Figure 2.10.1-2.

2.10.1.5 Discussion of Findings

The density of archaeological sites within the CGSA is unusually high compared to areas lacking obsidian sources. This is, to some degree, obviously a result of the unusual quantity of obsidian in the area: the sources at Sugarloaf Mountain and the pyroclastic obsidian throughout the study area contributed to a high intensity of aboriginal use in the region, and material was spread over a wide zone. About 50 percent of the inspected ground surface can be designated as one or another site type; i.e., the combined areas of the 153 sites identified amounted to approximately half of the area inspected. The sites tend to be large; 23 of those encountered were 100 acres or more in size. However, the density of artifactual materials on the ground surface is variable so that certain sites, for example around obsidian quarries, are densely scattered with tools and flakes whereas other sites have very light coverage. On the basis of the survey conducted, it is estimated that an average density of 4.5 sites per square mile would characterize the CGSA, a possible total of over 500 sites in the study area.

However, a walk-over survey of even 29 percent of the CGSA does not provide sufficient data to fully evaluate this unique area and further site-specific studies will be required.

It is not possible to provide a complete discussion of each site type here. However, one site type is of particular significance. Four rock art sites have been identified within the CGSA: three of these are petroglyph (carved or pecked) sites and one is a pictograph (painted) site. It has been noted that these sites are possibly the remains of aboriginal ceremonial activities (see also Heizer and Clewlow, 1973). In this sense they can be seen as significant, in terms of religous values, to Native Americans. As cultural resources they have also an important scientific value: rock art sites are rare archaeological specimens thought to be related to pre-historic belief systems (ibid). Finally, they have an artistic value beyond the above considerations. The fact that rock art sites in the Coso Range to the east of CGSA have been registered as National Historic Landmarks attests to their significance. The Coso Hot Springs and Prayer site, within the CGSA, have similarly been included on the National Register of Historic Places (see Glossary). With the exception of the historic remains at Coso Hot Springs, which are a part of the existing National Register site, the historic resources encountered during the survey are sparse and generally lacking in integrity and potential data yield.

The potential scientific value of the findings within the CGSA--as a whole and individually--is believed to be very high. For this reason, the eligibility of all or large portions of the area itself for inclusion in the National Register of Historic Places will be considered.

A determination of National Register eligibility, and an eventual thematic nomination, it is believed, would allow the greatest flexibility for future planning, development and scientific investigation. A thematic nomination is one which includes a finite group of resources related to each other in some distinguishable way by a common theme. (For example, all the courthouses in a county may be nominated, or all sites associated with a particular historic event.) All known properties linked by the chosen theme must be included, and the geographical area containing them must be defined.

The theme being considered for the CGSA as a whole is the human exploitation of the environment, over an extended period of time, in an area containing two important resources: a major obsidian source, and the Coso Hot Springs. Some unknown resources located outside the CGSA but clearly associated with aboriginal use of these two resources may later be uncovered and considered for inclusion in this theme; but at present, it is the cultural resources within the CGSA that are being assessed.

The study area as a whole, with its wide range of sites, long span of aboriginal occupation, and unique resource at Sugarloaf Mountain, has a potential for the investigation of a number of research questions which may be related to broader, regional problems in archaeology. For example, the CGSA can be considered part of two culture areas: The Great Basin and the Mojave

Desert. This area has influenced, and been influenced by, the California culture of the Kern River area, the Central Valley and possibly the coast. Thus, the CGSA is an area of contact of several major cultures and has provided a long-used corridor for the movement of people, trade goods and ideas among these areas (cf. Meighan, 1978). A detailed analysis of the archaeology within the CGSA could have implications for the interpretation of the archaeological record in these other areas as well. While all the identified sites are potentially as a whole, at least 15 sites are believed to have particular scientific value. These are listed below and further discussed in Chapter 3: ERG 253, ERG 273, ERG 340, ERG 313, ERG 316, ERG 373, ERG 375, ERG 268, ERG 380, ERG 381, DA 3, DA 9, DA 12, DA 28, and DA 35.

In summary, the prehistoric cultural resources of the CGSA are considered worthy of protection and considerable further study for a number of reasons: the high density of archaeological remains in the areas examined; the long span of human occupancy and wide rate of site types, including rock art; the generally high integrity of those remains within the NWC withdrawal, which has to a large extent protected them; and the presence of two unique resources which have been conducive to cultural contact between several major prehistoric cultures (Lanning, 1863; Meighan, 1978).

2.10.2 Impacts of the Proposed Action on Cultural Resources

2.10.2.1 Introduction

The eligibility of the cultural resources of the CGSA for inclusion in the National Register of Historic Places is expected to be determined in consultation with the State Historic Preservation Office (SHPO) during the ES review period. (In and of itself, inclusion in the National Register is not a mitigation measure. It does, however, provide a mechanism for developing and implementing such measures, as discussed in Chapter 3 of this ES.)

A number of recent legislative acts, Presidential directives, and implementing regulations have been designed to protect the nation's cultural resources. These include the Historic Preservation Act of 1966, Executive Order 11593 of 1971 on Protection and Enhancement of the Cultural Environment, the American Indian Religious Freedom Act of 1978, and portions of the Code of Federal Regulations pertaining to the National Register of Historic Places. Other legislation relevant to geothermal development contains specific clauses relating to protection of cultural resources. A brief description of the most relevant of these laws and regulations can be found in Appendix A. In addition, a Memorandum of Agreement (MOA) between the SHPO, the National Advisory Council on Historic Preservation and NWC has been executed by the SHPO and NWC and is currently before the National Advisory Council. This MOA addresses management of the existing National Register sites in the study area in compliance with 36 CFR, Chapter VIII, Part 800, as revised in 1978.

proper term is probably MOU - understandings

In conformance with this body of law, a Memorandum of Agreement between USGS and BLM, on cooperative procedures for protection of cultural resources related to geothermal lease operations, was also signed in June 1978 (WO 105); the text of this is included in Appendix C. In brief, this Agreement and subsequent memorandum provide that BLM shall make lease stipulations, which USGS shall enforce, (1) identifying and protecting known cultural resources on all geothermal leases, (2) requiring cultural resource surveys in accordance with BLM standards, and (3) in general providing for avoidance or necessary mitigation.

All of the mandated resources discussed above will be implemented as part of the proposed action. However, even with careful planning of geothermal development to avoid disturbance of cultural resources, there is potential for significant impact because of the high density of archaeological material in the CGSA. Site density is, in fact, so high that severe restriction of the proposed geothermal development might result if all archaeological material were to be avoided. It is expected that an average site density of 4.5 sites per square mile would be found throughout the CGSA, a possible total of over 500 sites within the study area as a whole.

While an average site size can be estimated, the figure is not as meaningful as one might wish. Within the 138 sample units (a total of 34.5 square miles examined), 153 sites were identified. It is estimated that these sites cover approximately one-half of the area inspected, or a total of 17.25 square miles. Average site size would thus be approximately 72 acres. However, site boundaries have not been tested. Furthermore, individual cultural manifestations range from isolated finds (e.g., single projectile points) to sites with an areal extent of over 600 acres; it would appear that 23 sites are 100 acres or more in size.

Within Geothermal Zone 1, there are four such sites, one exceeding 600 acres. One extremely high sensitivity area, the Coso Hot Springs National Register Site and Prayer Site, is found within this zone. Within this zone, the Coso Hot Springs area and the Prayer Site (see Figure 2.10.2-1) are both already on the National Register, will not be impacted by either the NWC geothermal development of the proposed action, because of protection by NWC policy. In addition, no archaeological impact is expected at the Prayer Site, since cultural remains there are sparse, randomly scattered surface lithic materials which are not likely to attract pothunters. Its listing on the Register is due to socio-religious attributes rather than archaeological remains. As a prayer site, however, it may be impacted as discussed in Section 2.3, 2.11, and 2.12. The area has special significance for Native American groups.

The proposed program will obviously have a potential for significant impact (up to 100 percent possible destruction of individual sites) with Zone 1. Such figures, of course, take no account of the density, nature, or condition of the individual deposits, but only the quantitative impact. If areas of extremely high sensitivity, such as villages, rock art, or burial sites, were

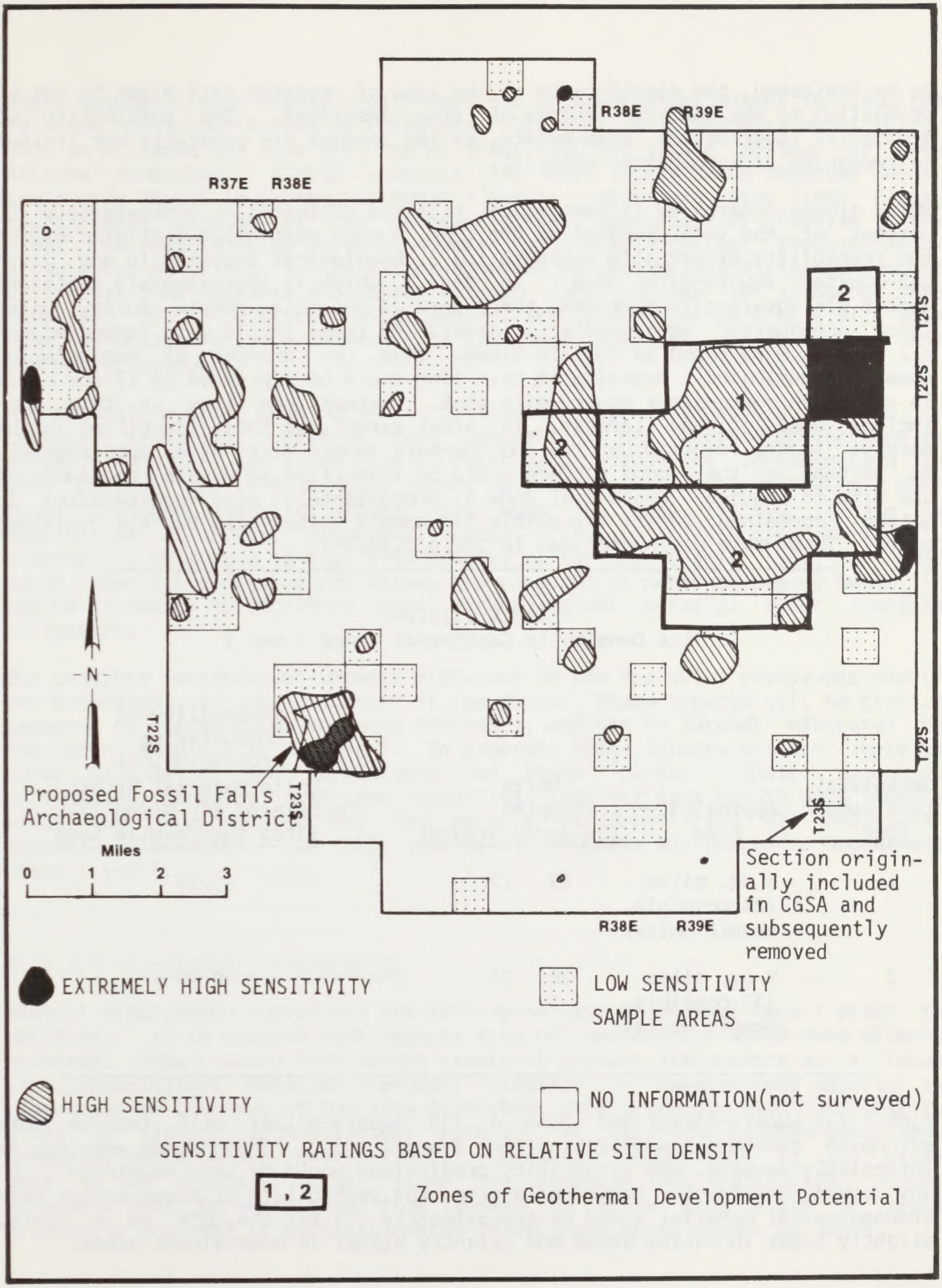


Figure 2.10.2-1. AREAS OF ARCHAEOLOGICAL SENSITIVITY

to be destroyed, the significance of the loss of research data might be out of proportion to the small percentage of area destroyed. The possibility of accidental destruction also exists, as lay persons are generally not trained to recognize archaeological material.

While ground covered by archaeological sites is estimated at approximately 50 percent of the total surface of the CGSA, a more meaningful statistic may be the probability of actually encountering archaeological deposits in any given one-quarter square-mile area. In Zone 1, which is approximately contained within six square-mile sections, there were 24 possible sample survey units (each one-quarter square-mile in area). Of these 24, 19 were inspected and all but two were found to contain sites. Thus, the chances of encountering some archaeological deposits in this zone could be expressed as 17 out of 19 in any given one-quarter square-mile plot. Further, the sites in this zone include some of the largest, in areal extent, of those identified in the survey; in one (contiguous) two and one-half square-mile area approximately 85 percent of the ground surface could be identified as within the bounds of one site or another. Geothermal Zone 2, approximately nine square-miles in extent, contained 28 (of a possible 36) sample units; all but six contained sites. These data are summarized in Table 2.10.2-1.

TABLE 2.10.2-1
Site Density in Geothermal Zones 1 and 2

Geothermal Development Zone	Approximate Area	Units Sampled (2-Survey Stages)	Units Containing Sites	Probability of Encountering Archaeological Material Within Any Given 1/4-Square-Mile Area
1	6 sq. miles (24 possible sample units)	19	17	0.89
2	9 sq. miles (36 possible sample units)	28	22	0.79

Zone 3 (31 square-miles) and Zone 4 (30 square-miles) will require more extensive geothermal exploration than Zones 1 and 2. These zones were not as intensively sampled, and probability predictions would be less meaningful. On any given one-quarter square-mile area, the probability of encountering some archaeological material would be approximately .75 for the CGSA as a whole, slightly lower in valley areas and slightly higher in mountainous areas.

Under standard lease terms, a site-specific archaeological survey is required in each developer's Plan of Operation. Sites of obviously high sensitivity, such as villages and rock art, can be identified and either avoided or data salvage conducted. Lithic scatters are more likely to be impacted due to their wide extent in Geothermal Zones 1 and 2; they are also less easily recognizable because of the abundant airfall (pyroclastic) obsidian in the area. The required site surveys, however, will enable further identification of cultural materials, and permit development of appropriate mitigation, which will range from complete avoidance through data salvage to allowing site integrity to be disturbed after preliminary survey (see Section 4.9). This last may occasionally be necessary to allow most efficient utilization of the geothermal resource.

All mitigation other than complete avoidance inherently causes impacts to cultural resources. Partial test excavations and surface collections to preserve some data can cause loss of other data because the investigation is only partial and it eliminates future options for research. Allowing a site to be disturbed ideally occurs only when the data it may contain is duplicative of other, preserved, sites. The loss in this case is minimal. However, in this area of high site density it is conceivable that, in some cases, when cultural resource values are compared to national energy needs, it may be necessary to sacrifice some archaeological material after feasible mitigation.

The possible "worst-case" impacts discussed in the following paragraphs should be considered in the context of the above. These impacts will be greatly lessened by the mandated measures discussed, and can be further mitigated by the plan proposed in Chapter 3. In general, these impacts are not likely to occur because of the regulations and lease terms. Their potential seriousness, however, and the resulting loss of data should such impacts occur, must be considered for the purpose of formulating all additional feasible mitigation. In this analysis, emphasis was placed on Geothermal Zones 1 and 2.

2.10.2.2 <u>Preliminary Exploration</u>

Minimal exploratory operations are anticipated for Geothermal Zone 1 prior to drilling; it is assumed that impacts from NWC exploration would have already occurred. Impact would nonetheless result if surface disturbance at a locus of archaeological material removes, displace or damages that material in proportion to the size of the area disturbed. The extremely high probability (.89) of finding archaeological material in this zone of high geothermal potential could be very restrictive of geothermal exploration if all sites were to be avoided. Other zones are somewhat less restrictive. Strong pressures could be anticipated from lessees to allow exploration in areas originally proposed if suitable nearby development areas cannot be found.

Gravity and magnetic measurements would not impact archaeological sites if these measurements are taken from aircraft. Impacts to cultural resources would result from off-road vehicle traffic which may occur in connection with measurements of micro-seismicity, and resistivity and magnetic measurements. If a site is located on the surface, as many of the sites appear to be, a large proportion of potential archaeological data may be lost as a result of driving or walking over archaeological remains. If the site includes a subsurface deposit, that portion of the data below the surface may remain undisturbed; hence, the proportion of total data loss would be smaller.

Drilling of holes for temperature gradient measurements in archaeological sites would destroy any subsurface material where the hole is drilled. (No drill pad, however, is required for heat flow measurements unless the ground is steep.) A small, dense lithic scatter could suffer virtual obliteration from such surface disturbance. A larger scatter would obviously experience proportionately less disturbance. In a dense scatter, 100 acres or more in area (several of which occur near Sugarloaf Mountain), the extent of impact from one acre of surface disturbance, could be characterized as less than one percent; the significance of the impact would depend on such factors as the density and character of the deposit. Disturbance of an extensive lithic scatter might be confined to an area of light coverage where the scientific value of the findings could be slight in comparison with the value of a particular petroglyph site or village.

2.10.2.3 Exploratory Drilling

The types of surface/subsurface disturbance described for the Preliminary Exploration phase would be magnified in this phase. Access road construction would impact archaeological sites by disturbing both surface and shallow subsurface deposits. Sites adjacent to the route, would be disturbed by grading and off-road parking of road construction equipment. New road construction would disturb from 1.7 acres to three acres for each mile of such road (see Chapter 1). An access road constructed through an archaeological site consisting of a surface and shallow subsurface deposit would disturb a small percent of a large lithic scatter but could destroy a very small site. The placement of gravel or cinder on the surface of the road would impact remaining subsurface archaeological deposits slightly by impeding access to the deposits in the future.

Drill site preparation would impact sites by clearing and leveling the land, which would remove both surface and subsurface archaeological deposits. Each drill pad would average 150' x 500' in area, but surface disturbance from pad preparation could amount to much more than this in rough terrain, because of increased cut and fill. The excavation of sumps and reserve pits approximately 150' by 150' and 10 feet deep would further impact archaeological deposits. One hundred percent of a small archaeological site at the locus of excavation, could be destroyed. As it is unlikely that an archaeological site in this area extends more than 10 feet below the surface, the excavation of a pit 10 feet deep would probably completely destroy any subsurface archaeological deposit encountered.

Drilling would impact whatever subsurface deposits remain after the leveling of the drill site. If the impact of site preparation has been major, resulting in the total or almost total destruction of the archaeological deposit, then the additional impact of well drilling would be considerably less.

Disposal of waste may impact cultural resources through breaching of sumps. Movement of heavy vehicles to dump or collect other waste in the waste sump may result in the accidental disturbance of adjacent archaeological deposits.

Extensive exploratory drilling prior to production in Zone 1 may not be necessary; more would be expected in Zone 2. In the event that a total of four well pads, eight sumps, four reserve pits, two reinjection wells and one mile of 13.8'-wide maintenance road were required in Zone 1 prior to production, a surface disturbance of at least 18 acres would result; this does not allow for extensive grading due to steep terrain, or for accidental spillage and clean-up. It is expected that approximately 16 of the 18 acres (89 percent) would contain sites or portions of sites, and that these could be impacted, depending on the mitigation measures used.

2.10.2.4 Field Development

Field development would have the most areal-extensive impact on archaeological sites; six well pads per 50-MW plant, together with sumps, etc. would be required. The length of operations and increased waste production will increase the probability of accidentally depositing waste on archaeological sites. The nature of the impacts, however, should be the same as that described for the exploratory drilling phase.

2.10.2.5 Resources Utilization

Some additional impacts to archaeological materials would occur during the operational phase of the program (within a given lease) as a result of the drilling of replacement wells; these impacts would be similar to those described for exploration drilling. In general, however, this phase of development would have less impact on archaeological resources than the preceding phases.

2.10.2.6 Closeout

Abandonment of wells would not impact archaeological resources. Restoration of the area, depending on how it is accomplished, may impact archaeological sites. For example, refilling of sumps and reserve pits, if accomplished by cutting other areas, could have archaeological impact in the area of excavation. If berms are bulldozed to their original grade and this material is used to fill sumps, any deposits contained in the berm would have already been disturbed, and additional data loss would probably be minimal. However, any surface, or shallow subsurface, materials at the original grade would be disturbed when the overburden is removed. Breaching of sumps which could occur at any time exploratory drilling to closeout could cause additional surface disturbance from the use of emergency vehicles.

2.10.2.7 Other Impact

The presence of numbers of workers, engineers and scientists in the CGSA is predicted to impact archaeological sites through an increase in amateur collecting and excavation, and possible vandalism of rock art sites. The rock art sites of Renegade and Petroglyph Canyons have been vandalized as a result of publicity and consequent heavy visitor traffic, and many of the sites encountered in the survey showed the effects of pothunting.

2.10.2.8 Summary of Impacts

Of the total of 2,260 acres disturbed in the course of full development (BLM leasing plus NWC), approximately 40 percent or 900 acres (five of the 11 plants and a smaller proportion of the total wells) would probably lie within Zones 1 and 2, an area of 15 square miles. It could be assumed conservatively that 450 acres of this disturbed surface area would constitute archaeological sites. The estimate of disturbed area in these two zones may also be conservative; it could be significantly greater due to the steepness of the terrain.

Given the extremely-high-sensitivity area within Zone 1, the severe topographic conditions (which may constrain plant locations), the relatively small size of this zone (six square miles), and the probable concentration of geothermal development there, the likelihood of impacting archaeological sites in Zone 1 is considered very high. For example, at least one section (640 acres) is required for one 50-MW plant and ancillary facilities, although only a small proportion (71 acres) of land disturbance would occur within that section. The survey data indicated that there is no complete section of 640 acres in Zone 1 without a known cultural resource site. It is clear from reference to the cultural resources site map (on file at the BLM Bakersfield office) that within Zone 1 there is no surface area of one square mile (regardless of section boundaries) without identified archaeological material, and that there being are one or two relatively flat areas of any extent outside of the National Register of Historic Places site. Thus, extreme care would have to be taken to avoid impact to cultural resources in Zone 1.

A few assumptions can be made regarding the placement of facilities; for example, it is conceivable that wellheads or pads might be located on top of rhyolite domes, though not sumps, reserve pits or power plants. However, it is not safe to assume that such locations would be without archaeological sites; in fact, several quarry sites are found on rhyolite domes.

In summary, the prediction is that approximately half of the surface of the CGSA (total 72,640 acres) contains cultural materials. If 2,260 acres were to be disturbed by geothermal development, total disturbed area would equal 3.1 percent of the total area, one-half of which (1.5 percent of the total) could be expected to contain archaeological/historical material. Put another way, half of the disturbed 2,260 acres, or 1,130 acres, could be covered with sites; the total disturbed area would constitute 3.1 percent of the predicted cultural resources in the CGSA.

In a worst possible case (however, statistically and administratively improbable), if every one of the 2,260 disturbed acres were found to be covered with sites, 6.2 percent of the cultural resources within the CGSA would be disturbed and destroyed.

Despite the NWC withdrawal, which has protected parts of the CGSA to a great extent, considerable pothunting has already taken place; and vandalism has been a significant problem within the region as a whole. However, the extent, variety, and overall condition of the CGSA's cultural resources (together with other known sites within the vicinity such as Petroglyph Canyon) are such as to present extremely valuable data for research into regional archaeological questions.

2.11 LAND USE

2.11.1 Present Land Use Setting

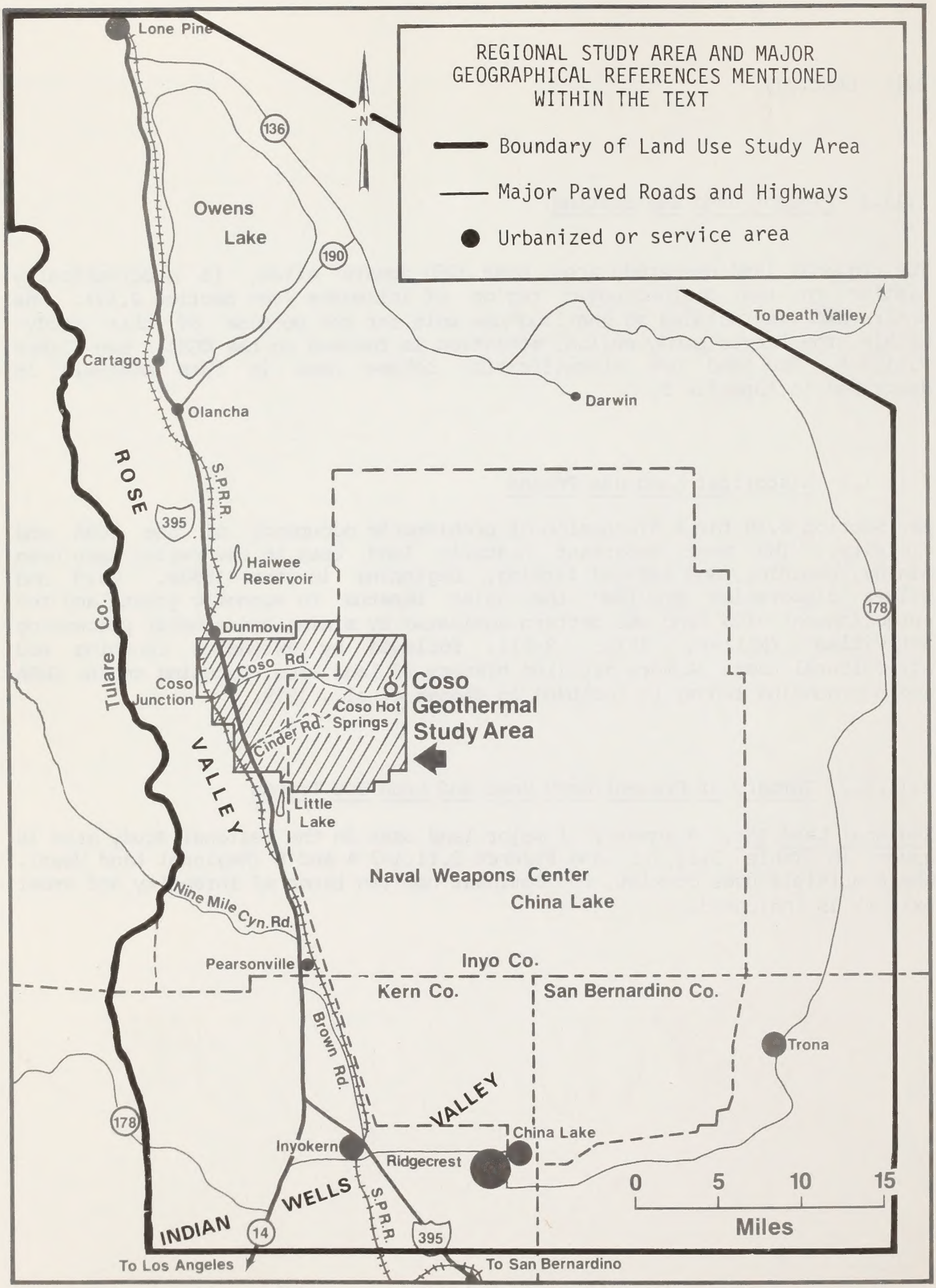
The regional land use study area, some 3250 square miles, is geographically similar to the socioeconomic region of influence (see Section 2.12). The entire NWC was included as one land use unit for the purpose of this study. Within the larger study region, attention is focused on the CGSA; see Figure 2.11.1-1. The land use classification scheme used in this analysis is described in Appendix F.

2.11.1.1 Historical Land Use Trends

See Section 2.10 for a discussion of prehistoric occupancy of the CGSA and vicinity. The most important historic land uses in the region have been mining, ranching, and limited farming, beginning in the 1860s. Gold and silver discoveries provided the major impetus to economic growth and the establishment of a land use pattern dominated by mining and mineral processing activities (Miller, 1976; 9-11), followed by extensive ranching and agricultural uses. A more detailed history of land uses, focusing on the CGSA and surrounding lands, is included in Brooks *et al.*, 1979.

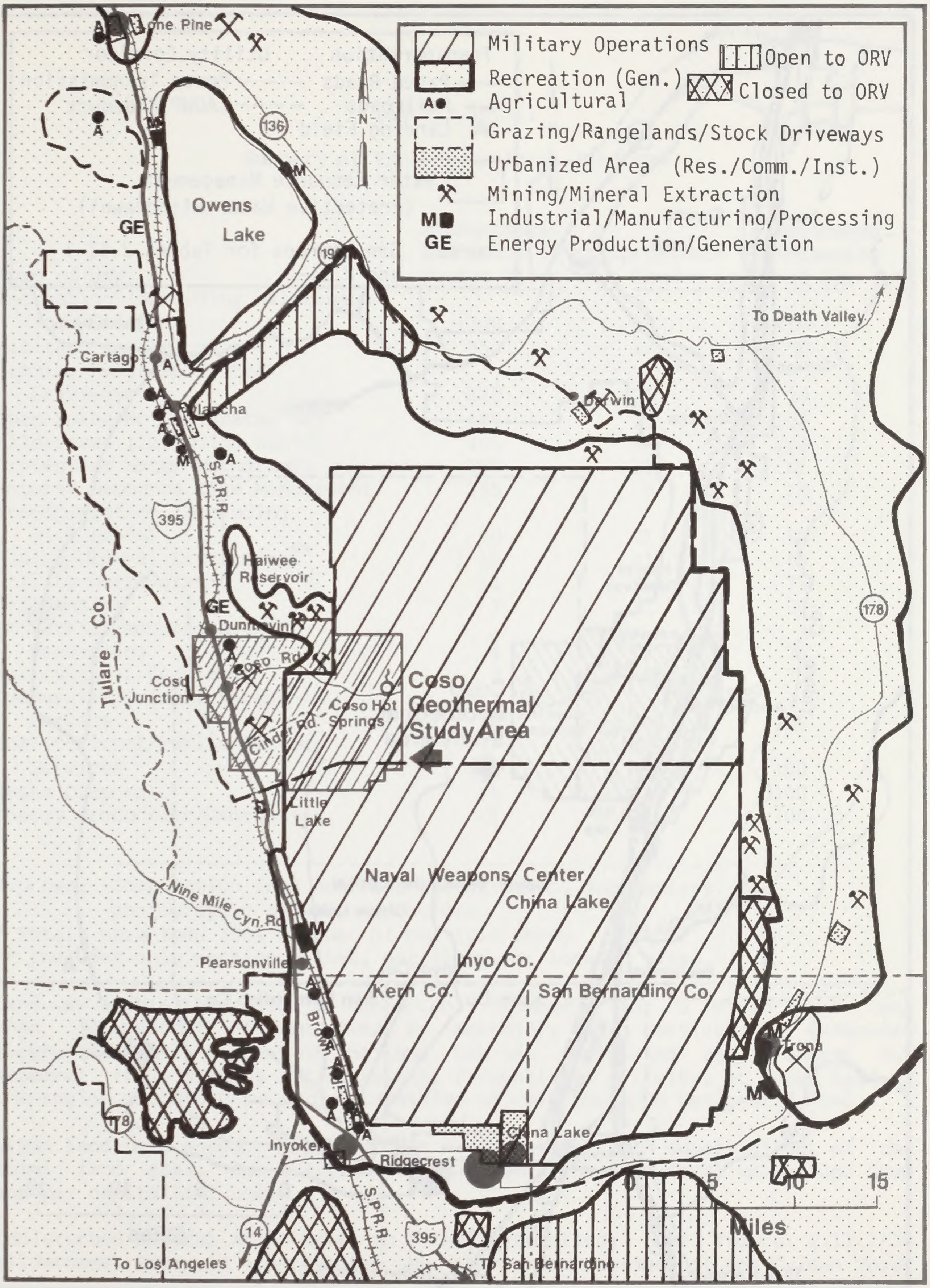
2.11.1.2 Summary of Present Land Uses and Land Use Trends

Regional Land Use. A summary of major land uses in the regional study area is given in Table 2.11.1-1 and Figures 2.11.1-2 A and B (Regional Land Uses). Where multiple uses coexist, the dominant use (in terms of intensity and areal extent) is indicated.



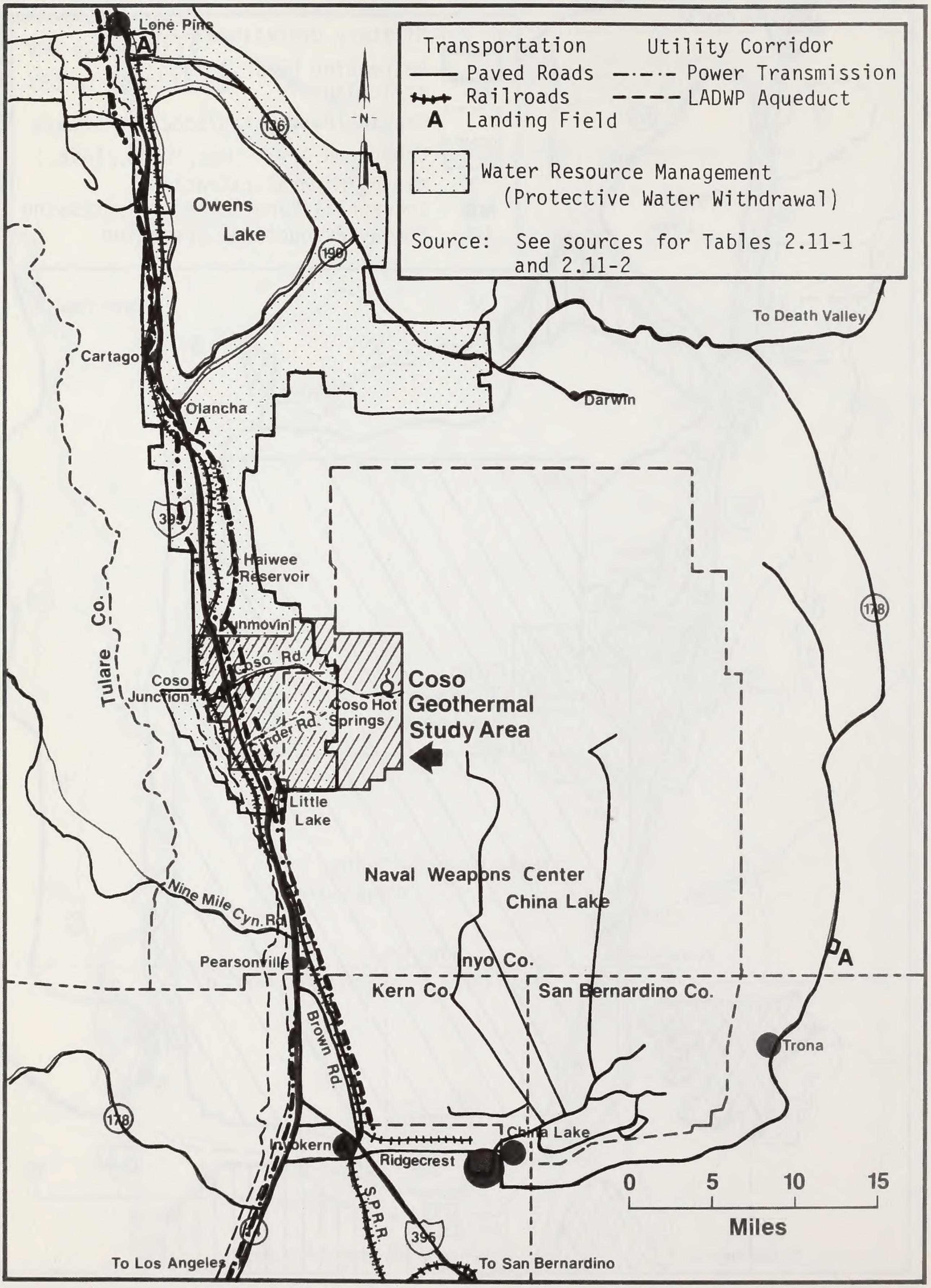
REGIONAL LAND USE STUDY AREA

Figure 2.11.1-1



REGIONAL LAND USE
(Generalized Areal Uses)

Figure 2.11.1-2A



REGIONAL LAND USE
(Generalized Lineal Uses)

Figure 2.11.1-2B

TABLE 2.11.1-1

Summary of Present Regional Land Use

Type of Use	Approximate Number of Square Miles	Approximate % of Region Area*	Estimated Intensity of Use (%)
Recreation (excluding Wilderness and WSA's)	1300	40	<10
Military Operation	950	30	50
Grazing/Rangelands/Stock Driveways	820	25	25
Open Space/No Designated Use	480	15	100
Wilderness (Including WSA's)	405	12	100
Protective Water Withdrawal	358	11	<1
Natural Resource Site Management	155	5	10
Transportation (excluding dirt roads)	20	<1	50
Mining/Mineral Extraction**	12	<1	50
Utility Corridor	11	<1	75
Residential	7	<1	50
Industrial/Manufacturing/ Processing	4	<1	75
Agricultural/Croplands	3	<1	75
Commercial/Private Sector Service	2	<1	100
Institutional/Public Sector Services	1	<1	100
Waste Disposal	<1	<1	100
Energy Production/Generation	<1	<1	100

Sources: Compilation from numerous cartographic, documentary, photographic and survey sources.

* Totals more than 100% because of multiple uses.

** Includes only working sities, not claims or located sites.

Land use within the region is not notably intensive (for a given use, less than 30 percent of the time on average), nor particularly extensive (approximately 15 percent of the land has no designated use; except for seasonal range grazing and occasional recreational activity, at least half of the region would otherwise be classified as Open Space/No Designated Use).

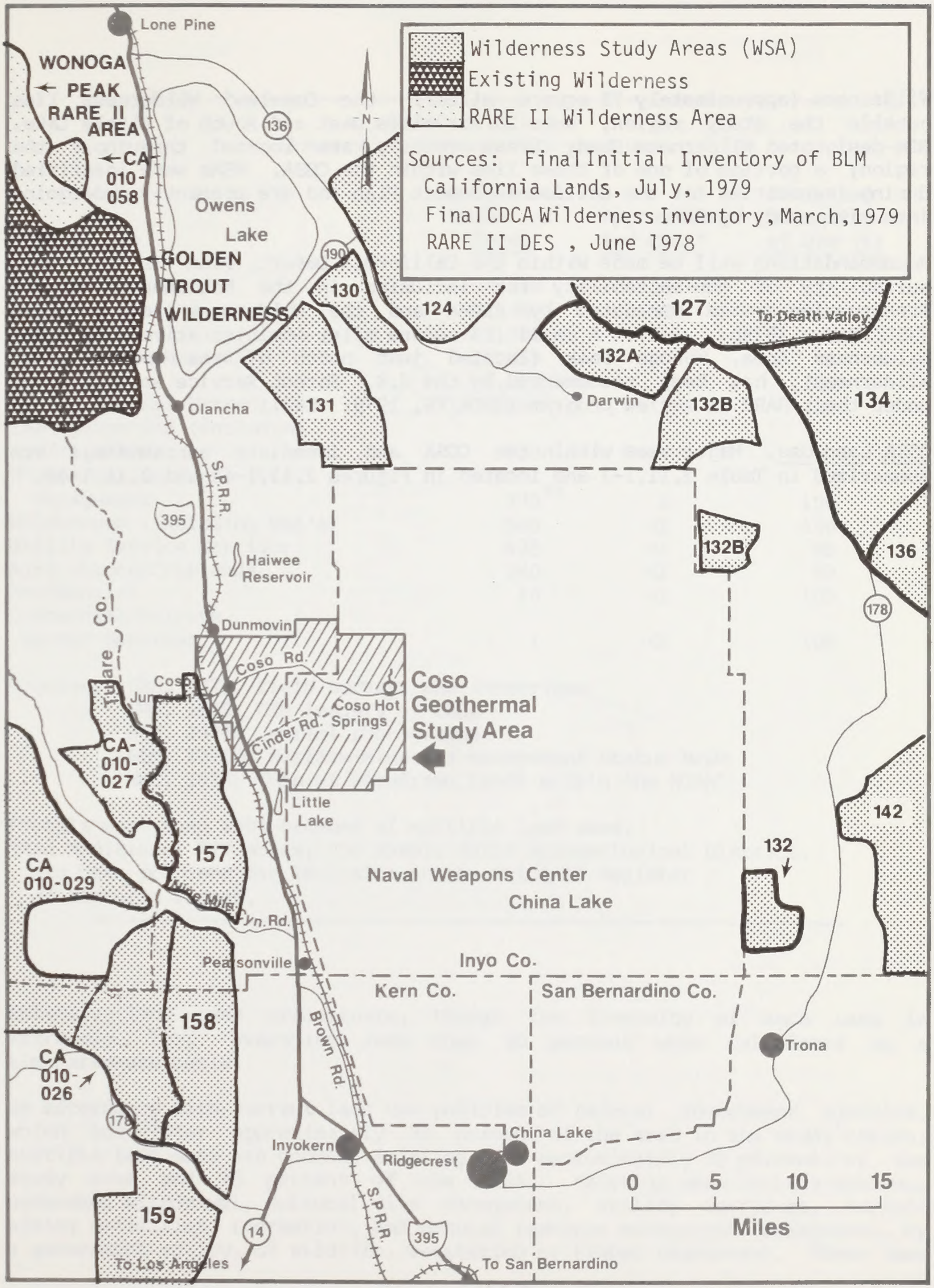
Urban land uses account for less than 0.4 percent (12.25 square miles) of the total land area. Table 2.11.1-2 summarizes present regional urban land uses and per capita land use.

Undisturbed natural areas exist in three categories; see Figure 2.11.1-3. Wilderness Area is represented by the eastern edge of the Golden Trout

Table 2.11.1-2 SUMMARY OF PRESENT REGIONAL URBANIZED AREA LAND USES
(all figures in square miles)

Greater Urbanized Area	Estimated Population (1980)	Urbanized Surface Area	Per Capita Urbanized Land Use	Residential	Commercial/ Institutional	Industrial/ Manufacturing	Transportation
Ridgecrest/China Lake (excluding NWC operations)	21,900	8.0	0.00038	4.8	2.1	0.6	0.5
Trona/Searles Valley	4,460	1.6	0.00036	0.6	0.15	0.7	0.15
Inyokern/Brown-Road (includes Inyokern Airport)	3,200	1.3	0.00041	0.2	0.7	0.03	1.0
Lone Pine (includes Indian Reservation and Airport)	1,750	1.2	0.00068	0.4	0.2	<0.01	0.6
Olancha/Cartago/Grant	550	0.15	0.00029	0.1	<0.01	<0.01	0.05
TOTALS for Urbanized Areas Within Study Region	31,860	12.25	0.00042 (regional average)	6.1	2.55	1.3	2.3
Non-Urban Area TOTALS	2,100	-	-	0.9	0.45	2.7	17.7
Regional TOTALS (Urban and Non-Urban Areas)	33,960	-	-	7.0	3.0	4.0	20.0

Sources: General Plans and Plan Maps for Ridgecrest, Inyo County, Kern County, San Bernardino County.
ERG, 1979, field survey and checking.
BLM, 1976, aerial photography
Section 2.12 of this ES



WILDERNESS AND WILDERNESS STUDY AREAS

Figure 2.11.1-3

Wilderness (approximately 72 square miles); the Domeland Wilderness lies outside the study region, some 20 air miles west and south of Little Lake. BLM-designated Wilderness Study Areas (WSAs), are located throughout the region; a portion of one of these lies within the CGSA. WSAs were identified during inventories for the California Desert Plan and are presently undergoing intensive study by BLM.

Recommendations will be made within the California Desert Plan as to their suitability or non-suitability for inclusion in the National Wilderness Preservation system manadated by FLPMA and the Wilderness Act of 1964 (USDI/BLM, 1979b: 231). A small (15 square mile) Administratively Endorsed Wilderness Area, Wonoga Peak (located just north of the Golden Trout Wilderness), has been recommended by the U.S. Forest Service as wilderness under their RARE II review program (USDA/FS, 1979: C-3).

CGSA Land Use. Major uses within the CGSA and immediate surroundings are summarized in Table 2.11.1-3 and located in Figures 2.11.1-4A and 2.11.1-4B.

TABLE 2.11.1-3
Summary of Present CGSA Land Use

Type of Use	Approximate Number of Acres	Approximate % of CGSA*	Estimated Intensity of Use (%)
Grazing/Rangeland	69,440	96	25
Military Testing	44,480	57	10
Recreation	27,300	38	<5
Watershed Withdrawal	19,250	27	<1
Open Space	3,200	4	100
Mining/Mineral Extraction	1,400	2	35
Transportation (including dirt roads)	850	1	50
Historical/Cultural Site Management	730**	1	100
Wilderness (including WSA's)	500	<1	100
Utility Service Corridor	435	<1	90
Agriculture/Croplands	340	<1	90
Residential	10	<1	100
Commercial/Private Sector Services	1	<1	100

Sources: ERG, 1979, field surveys and interviews
ERG, 1978, CIR imagery of CGSA
BLM, 1976a, aerial photographs
BLM, 1976b, Surface-Minerals Management Status Maps
NWC, 1978, "Map of Withdrawn Lands within the KGRA"

*Totals more than 100% because of multiple land uses.
**An additional 770 acres, the Fossil Falls Archaeological District, has been proposed for inclusion on the National Register of Historic Places.

Extensive land uses predominate, though the intensity of such uses is extremely low, averaging less than 20 percent when calculated on a time/area-use basis.

In accordance with current land use policies of Federal government agencies, which administer approximately 92 percent of the area in the study region, multiple land uses are common, existing over approximately 35 percent of the study area and 95 percent of the CGSA. Existing uses include grazing, watershed withdrawal, cultural site management, utility corridors, surface mining activities, recreation, and natural resource management (management, by a government entity, of wildlife, vegetation or timber resources). These uses

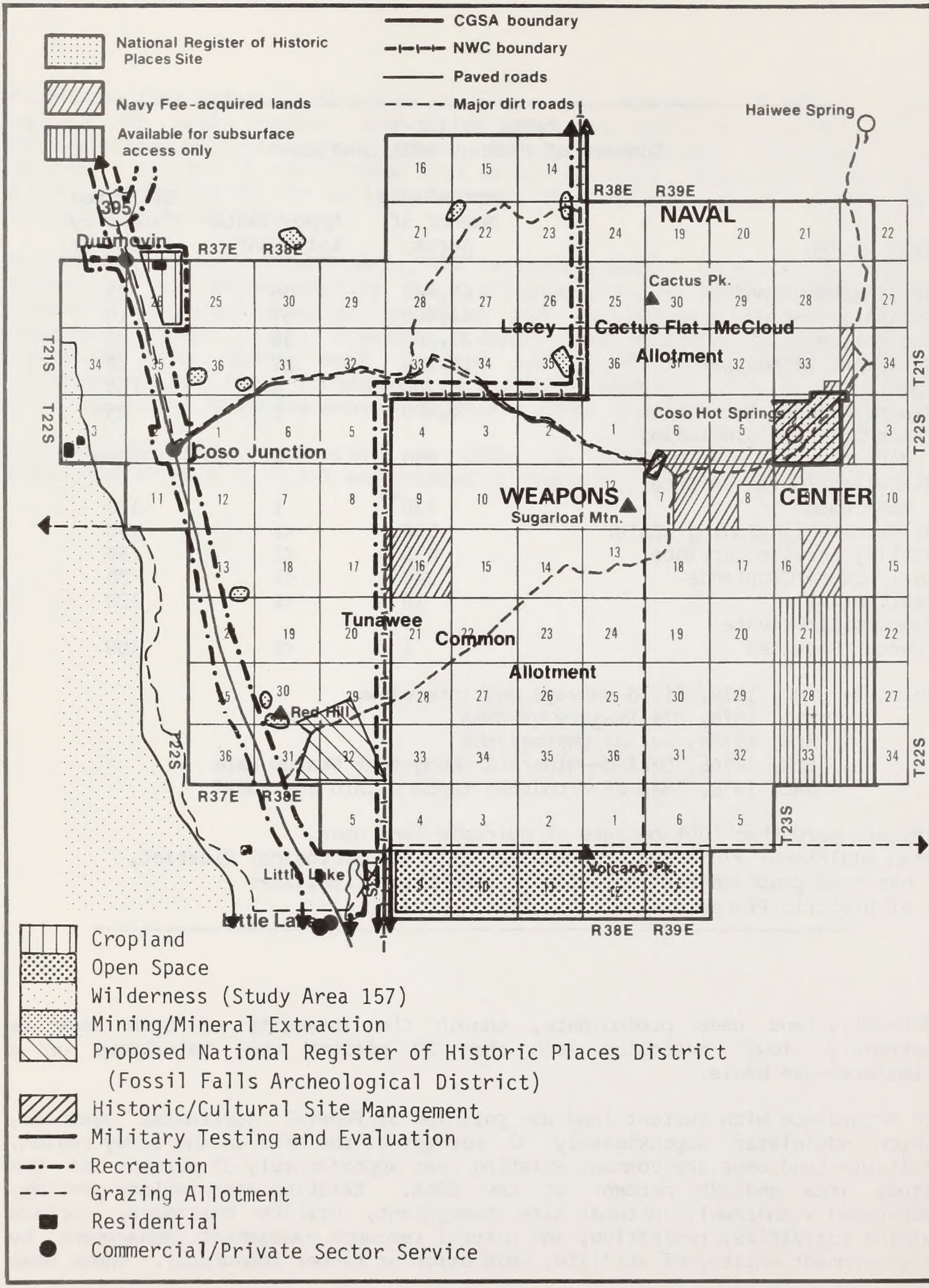


Figure 2.11.1-4A. PRESENT CGSA LAND USE (AREAL USES)

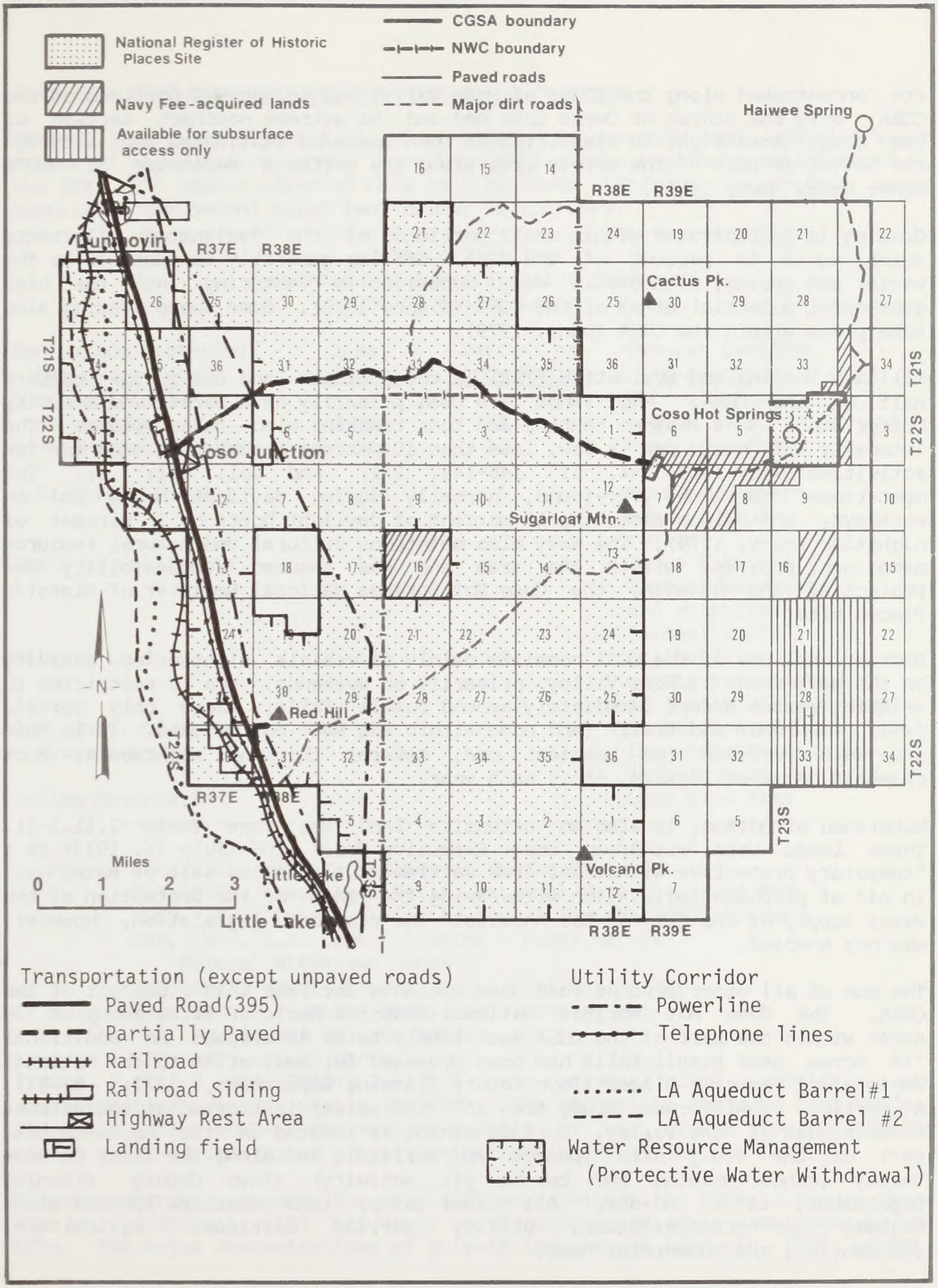


Figure 2.11.1-4B. PRESENT CGSA LAND USE
(LINEAL USES AND PROTECTIVE WATER WITHDRAWALS)

are concentrated along the floor of Rose Valley and in non-NWC portions of the CGSA; only the center of Owens Lake bed and the extreme southern section of the study area might be classified as Open Space/No Designated Use, although the latter is part of the safety area along the northern perimeter of NWC's Baker Range (NWC, 1979).

Grazing is concentrated within small portions of the designated allotments which cover 96 percent of the CGSA. Grazing generally is confined to the winter and spring, with cattle only occasionally venturing into the high geothermal potential areas of the CGSA (Elton, 1979). Some sheep grazing also take place within the CGSA (Lane, 1979).

Military Testing and Evaluation (T&E) is the dominant land use in the eastern half of the CGSA. NWC lands are used primarily as a safety and security buffer zone. Some weapons testing and test tracking also takes place. The intensity of Navy use is low, less than 10 percent actual time used for T&E activities (NWC, 1979, Vol. I: 148-149, 221; and Vol. II: 9). T&E operations continue year-round, normally during daylight hours and on weekdays; and seldom exceeding 10 percent of daylight hours or 2 percent of nighttime (Macy, 1979). The Navy also maintains cultural and natural resource management programs within the area and has assumed responsibility for protecting and managing the Coso Hot Springs National Register of Historic Places site.

Recreational use of the CGSA consists mainly of vehicle sightseeing activity on the back roads of Rose Valley, primarily on weekends. Use is restricted to existing routes except immediately around Fossil Falls, where only certain designated roads and trails (and none within the NWC) may be used. It is this area which receives the heaviest use, several thousand sightseers, rock climbers, rock collectors, etc., each year.

Watershed withdrawal is also an extensive land use (see Table 2.11.1-3). These lands were withdrawn under Executive Order 6206 (July 16, 1933) as a "temporary protective withdrawal from settlement, location, sale or entry ... in aid of proposed legislation withdrawing the lands for the protection of the water supply of the City of Los Angeles." The proposed legislation, however, was not enacted.

The sum of all other present land uses accounts for less than 6 percent of the CGSA. The Coso Hot Springs National Historic Register Site, occupies 730 acres within the part of the CGSA most likely to be developed. An additional 770 acres near Fossil Falls has been proposed for nomination to the National Register of Historic Places (Inyo County Planning Department, 1979: 82-83). A portion of Wilderness Study Area 157 (500 acres) is located at the extreme western edge of Rose Valley. Surface mining is located in the north-central part of the study area (pumice and perlite), and along the floor of Rose Valley (cinder mining and borrow pit activity) (Inyo County Planning Department, 1979: 60-66). All other minor land uses are located along Highway 395--transportation, utility service corridor, agriculture, residential, and commercial uses.

nothing on hunting use

2.11.1.3 Land Ownership and Administrative Patterns

Table 2.11.1-4 and Figure 2.11.1-5 show present ownership and administrative status of study region lands. More than half of the region is administered by the BLM; 330 square miles of this land has been withdrawn to protect water supplies. The second major land holder is the Navy.

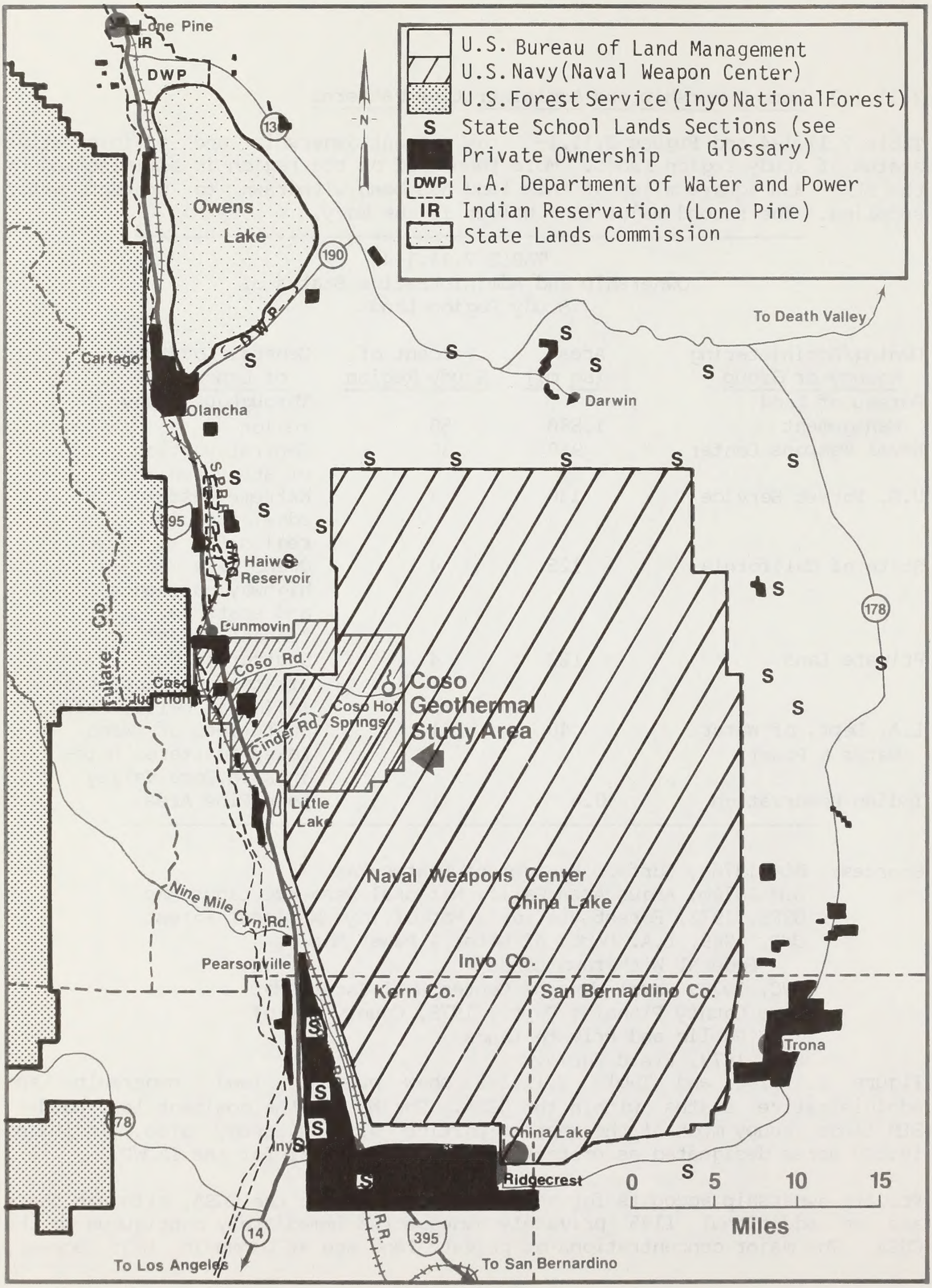
TABLE 2.11.1-4
Ownership and Administrative Status of Study Region Lands

Owning/Administering Agency or Group	Area (sq mi)	Percent of Study Region	General Location of Lands
Bureau of Land Management	1,880	58	Throughout study region
Naval Weapons Center	950	30	Central portion of study region
U.S. Forest Service	130	4	Extreme western edge of study region
State of California	125	4	Owens Lake Bed, highway easements, and scattered "school lands"
Private Land	122	4	Scattered, but greatest concentration in Indian Wells Valley
L.A. Dept. of Water Water & Power	40	1	Shorelines of Owens Lake; scattered holdings in Rose Valley
Indian Reservation	0.4	<1	Lone Pine Area

Sources: BLM 1976a, Surface Management Status Map
BLM 1976b, Argus Area Calif. National Resource Lands Map
USFS, 1972, Forest Visitor's Map of Inyo National Forest
DWP, 1969, L.A. Dept. of Water & Power Map of Federal Withdrawn Lands
NWC, 1978, Naval Weapons Center Real Estate Map
Inyo County Planning Dept., 1978, County Map of Public and Private Lands
ERG, 1979, Field Survey

Figure 2.11.1-6 and Table 2.11.1-5 show present land ownership and administrative status within the CGSA. The NWC is the dominant land holder. BLM lands occupy much of the western portion of the study area, including 19,520 acres designated as protective water withdrawal for the LADWP.

Private ownership accounts for only 1710 acres within the CGSA, although there are an additional 1195 privately owned acres immediately contiguous to the CGSA. The major concentrations of private land are at Dunmovin (855 acres),



REGIONAL LAND OWNERSHIP AND ADMINISTRATIVE STATUS

Figure 2.11.1-5

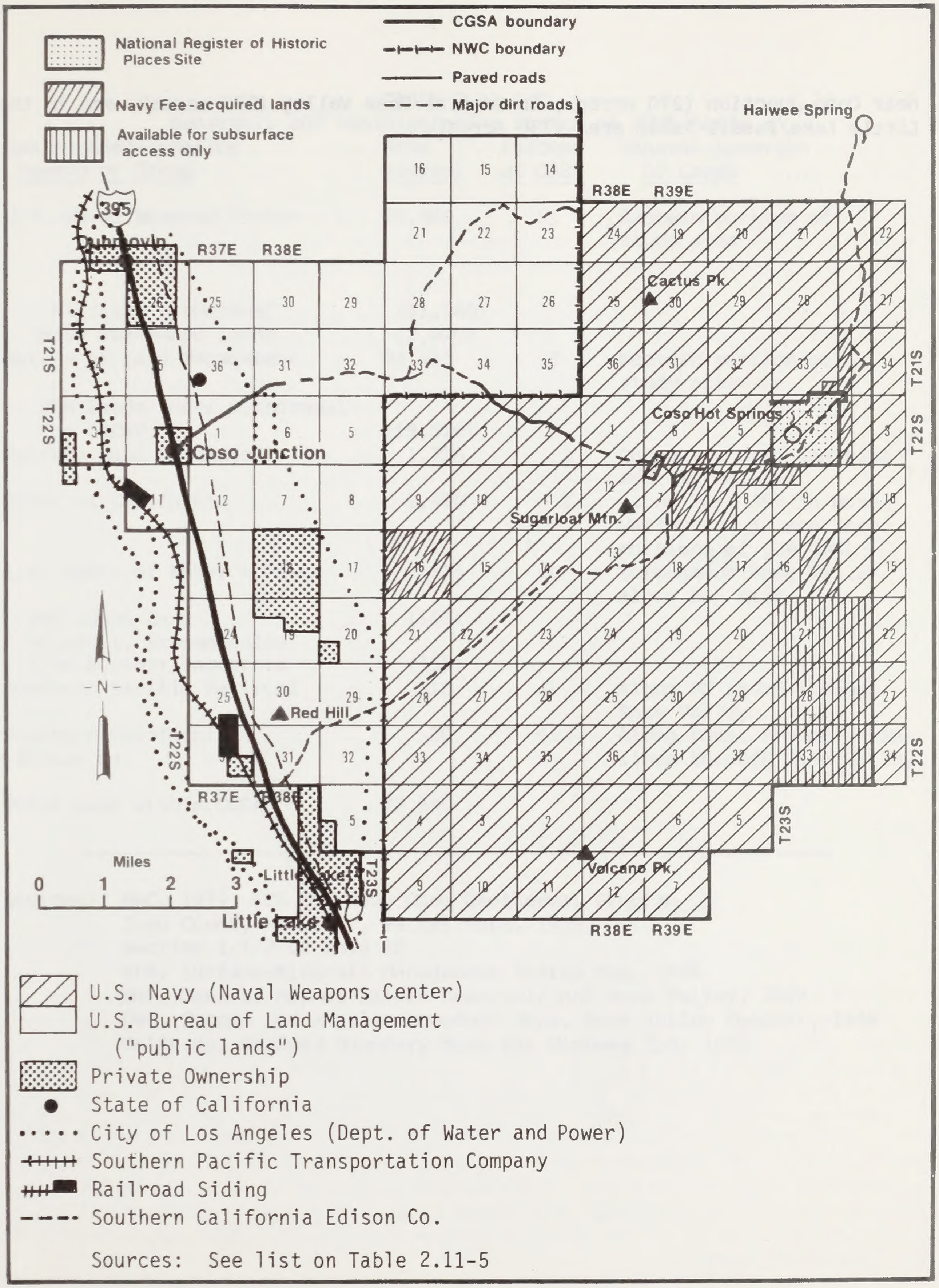


Figure 2.11.1-6. CGSA LAND OWNERSHIP AND ADMINISTRATIVE STATUS

near Coso Junction (270 acres), in central Rose Valley (970 acres), and in the Little Lake/Fossil Falls area (730 acres).

TABLE 2.11.1-5
Ownership and Administrative Status of CGSA Lands

Owning/Administering Agency or Group	Area (acres)	Percent of CGSA	General Location Of Lands
U.S. Naval Weapons Center	44,480	61	Eastern portion of study area
Military Withdrawal	(41,560)		
Navy Fee-owned lands	(2,920)		
Bureau of Land Management	24,115	33	Western portion of study area
BLM lands under withdrawal for LADWP	(19,520)		
Private Land Holdings	1,710	2	Dunmovin, Coso Junction and Little Lake
State of California	1,490	2	Along Hwy. 395 in Rose Valley and in scattered portions of the CGSA
L.A. Dept. of Water & Power	515	<1	Throughout Rose Valley along N-S axis.
Fee-owned Land	(160)		
Aqueduct, transmission line & other easements	(355)		
Southern Pacific Railroad	310	<1	Along RR route through Rose Valley
Southern California Edison Co.	20	<1	Along power transmission lines through Rose Valley
Total Land within CGSA	72,640		

Sources: NWC, 1979, FES for Navy Coso Geothermal Program
Inyo County Assessor, Parcel Maps, 1979
Section 1.1.2 of this ES
BLM, Surface-Minerals Management Status Map, 1976
DWP, General Map of Haiwee Reservoir and Rose Valley, 1978
DWP, Second Los Angeles Aqueduct Maps, Rose Valley Conduit, 1968
CalTrans, Roadway Boundary Maps for Highway 395, 1976

2.11.1.4 Present Land Use Policies, Plans, and Permitted Uses

Public lands within the CGSA are administered under the general provisions of FLPMA, which requires that a master land use plan be prepared for the entire California Desert Conservation Area, including the CGSA. This plan, presently in preliminary draft form, will become the guide to public land use in the area. No other BLM land use plans exist for the area. Geothermal exploration and development is presently considered a permitted use for the CGSA.

NWC portions of the CGSA are subject to the provisions of the NWC Master Plan, which acknowledges the desirability and compatibility of multiple land uses on NWC portions of the CGSA. (NWC, 1974: E5-33). At the same time, the Navy is concerned about possible encroachment on their test ranges; NWC policy is to discourage incompatible development activity around the perimeter of the NWC and generally to prohibit non-NWC development or use of base lands (Saxton, 1978, see also NWC 1979a: 168). The Navy also has specific cultural and natural resource management plans for their lands and has executed several land use/management agreements with other federal and state agencies related to grazing, fish and game, and energy resources.

will geothermal explor + devel interfere with agreements?

Inyo County's 1990 General Plan is presently being updated and will reflect the possibility of development activities in Rose Valley (Budlong, 1979). The Land Use Element of the new General Plan will not be completed until early 1980. Presently the CGSA is zoned as Open Space, with all development requiring a Conditional Use Permit (de Hart, 1979). The Inyo Mono Association of Government Entities General Plan designates Rose Valley as a "recreation area" (IMAGE, 1977: 26-30). Inyo County also has a Geothermal Ordinance which would govern certain land development activities of the proposed action.

2.11.2 Impacts of the Proposed Action on Land Use

2.11.2.1 Direct and Indirect Land Use Impacts of Proposed Program

In general, direct land use impacts of the proposed action are expected to be minor or insignificant (see following paragraph for definition of terms) except under certain of the full-development conditions, and most impacts are limited to Zones 1 and 2 of the CGSA. Indirect impacts are also few, becoming severe only under certain "worst case" assumptions; most of these impacts are focused on western portions of the CGSA and study region. See Figure 2.11.2-1 to locate probable impact concentration zones within the CGSA and land uses most likely to be impacted. Table 2.11.2-1 provides a summary of the expected significant land use impacts. In this table, the use of plus and minus signs denotes only the expected additional (or diminished) acreage in a given category as a result of the proposed action and does not refer to a "positive" or "negative" impact.

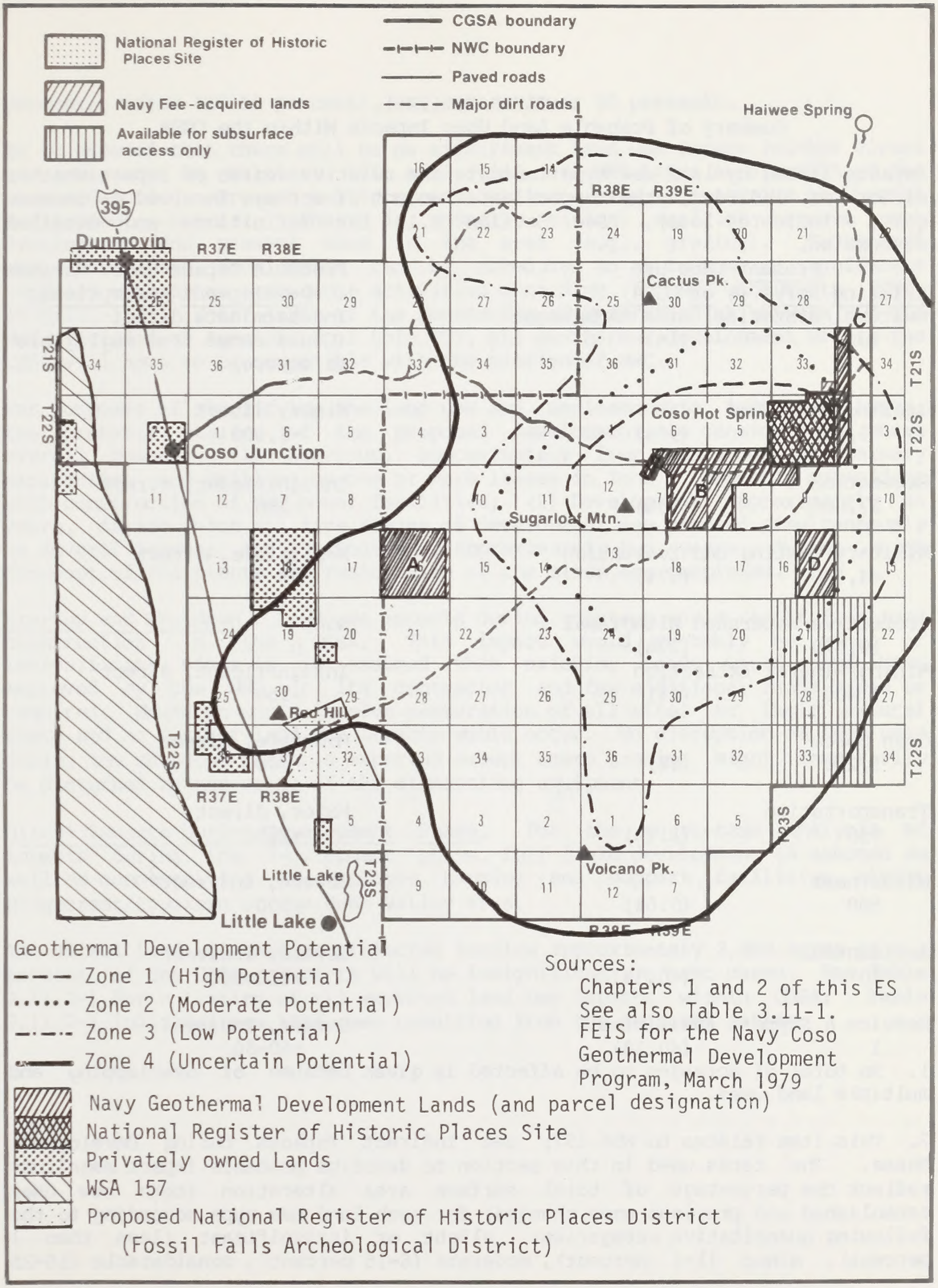


Figure 2.11.2-1. CGSA LAND AREA LIKELY TO BE IMPACTED

TABLE 2.11.2-1
Summary of Probable Land Uses Impacts Within the CGSA

Impacts listed by land use type indicate the relative degree of impact whether direct or indirect, the approximate amount of acreage involved (+ denotes gain, - indicates loss). See Section 2.11 for definitions and detailed discussion.

Present Land Use — Existing Acres	(% of CGSA)	Probable Impact Under Maximum Development Assumptions[1]
Cultural/Historical Site Management		Indeterminate, direct
730	(1%)	(Could range from negligible to severe)
Grazing/Rangeland		Minor, direct
69,440	(96%)	-2,000
Recreation		Insignificant, direct
27,000	(38%)	-200
Military Testing and Evaluation		Negligible, direct
44,480	(57%)	0
Protective Watershed Withdrawal		None
19,520	(27%)	0
Mining/Mineral Extraction		Insignificant, direct
1,400	(2%)	-150
Open Space		Moderate, direct
3,200	(4%)	-300
Transportation		Major, direct
850	(1.2%)	+225
Wilderness		Severe, indirect[2]
500	(0.6%)	-500
Residential		Severe, indirect
10	(<0.1%)	+150-200
Service & Support Facilities		Severe, indirect
1	(<0.1%)	+60-80

1. No total of acreages to be affected is given because of overlapping and multiple land uses.

2. This item relates to WSA 157; see Indirect Impacts During Development Phase. The terms used in this section to describe probable impact magnitude reflect the percentage of total surface area alteration (both new uses established and previous uses changed) for each land use type according to the following quantitative categories: slight or insignificant (less than 1 percent), minor (1-5 percent), moderate (6-15 percent), considerable (16-25

percent), major (26-50 percent), and severe (over 50 percent).

It is assumed that there will be no significant land use impact (either direct or indirect) on Military T&E activities or NWC lands as a result of the proposed action. Present multiple uses continue, even if extensive geothermal development occurs. There is normally minimal conflict between such development and present uses in the area (e.g., grazing). Geothermal exploration and development can be scheduled so as to pose no significant conflict with other test range activities according to NWC documents (NWC, 1979:151-152). Under terms of the Memorandum of Understanding between BLM and NWC (included as Appendix C of this ES), all geothermal development within the CGSA will have to be compatible with the mission of NWC.

For purposes of simplifying the land use and socioeconomic impact analyses, the probable staging of the proposed development is considered in three overall phases: (1) Start-up, approximately four years of preliminary exploration and drilling on one or more leases in Zone 1, probably coincident with construction of NWC power facilities; (2) Development, approximately 45 years, during which all five stages of development may proceed simultaneously on several leases; and (3) Shutdown, approximately two years, during which closeout of the plants and restoration of the sites are completed.

<u>Startup and Shutdown</u>. Land use impacts during start-up would result from road construction in the CGSA. This impact would probably be minor or insignificant, since it is assumed that existing roads would have been improved by the NWC or its contractor and few additional roads would be required. Shutdown would involve restoration of all sites to their natural state and no further land use impacts would occur. No disruption of land uses during the shutdown phase is expected except where grazing might temporarily be disturbed by the noise of the dismantling equipment.

<u>Direct Impacts During Development Phase</u>. For the worst-case analysis of impacts during the development phase, full field development is assumed as well as concentration of employee housing and support facilities within Ridgecrest/Inyokern or the Rose Valley area.

The direct land use changes projected involve approximately 2,260 acres or 3.1 percent of the CGSA. Impacts will be insignificant in most cases. See Table 2.11.2-1 for a listing of all expected land use impacts within CGSA; Table 2.11.2-2 indicates new land uses resulting from the proposed action.

TABLE 2.11.2-2 Possible New Land Uses Within the CGSA Resulting from the Proposed Action

New CGSA Land Use (of Units)	Acreage	%CGSA	Approximate Land Use Intensity (%)	Probable Use Incidence
Sumps and Reserve Pits (1,198)	695	0.96	100	Occasional during project life
Production Wells and Pads	623	0.86	75	Intermittent
Maintenance Roads (229 miles)	377	0.5	100	Frequent
Injection Wells and Pads (216)	217	0.3	75	Intermittent
Access Roads (22 miles)	67	0.09	100	Constant
Power Plant (11)	66	0.09	100	Constant
Abandoned Well Pads (22)	65	0.09	10	Rare
Transmission Lines (19 miles)	29	0.04	20	Constant
Water (makeup) Pipeline (8 miles)	10	0.01	5	Occasional
Transmission Line Road (8 miles)	7	0.01	100	Constant
Rose Valley Substation (1)	2	<0.01	100	Constant
SUBTOTAL	2,258	3.12		
Additional CGSA Land Possibly Developed for Indirect Support Facilities	280	0.38	75	Constant, past field life
TOTAL	2,538	3.5%		

Sources: Chapter 1 of this ES. USGS 15' Topographic Quadrangles for Haiwee Reservoir (1951) and Little Lake (1954).
Field Survey (1978-1979) conducted by ERG. Chapter 2 of this Environmental Statement.

If 250 miles of roads were needed for geothermal development (assuming that approximately one-half of these roads would use existing rights of way or NWC roads) the total additional road area needed would be approximately 225 acres, a 26 percent increase. Approximately 2,000 acres of existing grazing allotment land might be lost temporarily, including area fenced off or closed to grazing animals. This impact is considered only minor.

Some 300 acres of existing Open Spaces uses in development 4 could possibly be diverted for geothermal development; however, this area is in a remote and presently inaccessible portion of the NWC (south of Volcano Peak). Direct impacts on Recreational land uses will also be minor, resulting from the loss of approximately 200 acres of land presently suitable for such use. There is the likelihood of impacts resulting from increased sightseeing activity within the development area (outside the NWC) by curious tourists, because of the unique nature of this Project. This would create additional disturbance of "natural" characteristics of the area for those seeking recreation in remote areas.

Geothermal development is not anticipated to interfere with current or projected mineral production in the area. The only limitations foreseen would be possible coordination of traffic patterns for optimum utilization of access roads, possible limitations on water availability for new mineral production activities, and placement of geothermal facilities not to coincide with any mineral production area.

There is an indeterminate possibility of direct impact on Cultural/Historical Site Management land use at Coso Hot Springs, as discussed under Hydrology, and Socioeconomics (Native American Concerns). Direct impact, under full field development of Zones 3 and 4, might also take place near the area proposed for nomination to National Register status northeast of Fossil Falls.

Indirect Impacts During Development Phase. The most significant land use impacts will be indirect, resulting from the need to provide residential and support facilities for 375 to 500 employees and families (see Section 2.12.1). In the "worst case" analysis the focus of growth and the creation of new support and service facilities is postulated for Rose Valley. Indirect land use impacts would be moderate to severe, requiring a possible 280 acres. Total available privately owned land in Rose Valley comprises 1,710 acres, now mainly used for grazing and alfalfa farming; from 12 to 16 percent of this would be required, resulting in the complete loss of present uses on land designated for development. The intensity of new uses would be high, of long duration, and constant for at least the life of the program.

Geothermal development in those portions of Zones 3 and 4 visible from Highway 395, and any development of support and service facilities within Rose Valley, would slightly lessen the wilderness character of the 500 acres of Wilderness Study Area (WSA) 157 which is located within the CGSA. WSA 157 is presently under intensive study prior to possible recommendation for Congressional designation as a Wilderness Area. In accordance with FLPMA, Section 603, designated Wilderness Study Areas will not be allowed to be impacted by the proposed action.

2.11.2.2 Conflicts with Existing Land Use Plans and Policy

The proposed action poses no significant conflict with relevant existing land use plans and policies of management control agencies, with the possible exception of developing residential and service facilities in Rose Valley under "worst case" assumptions. Such uses may be incompatible with NWC and Inyo County policies.

2.11.2.3 Probable Future Land Use Trends as a Result of the Proposed Action

Since most of the land within the CGSA is administered by Federal agencies, it is unlikely that future land use trends would differ significantly from the present, unless management policies of these agencies are altered as a result of development pressures generated by the proposed action. The limited private land within Rose Valley may experience considerable pressures for change in use as a result of the proposed action however, depending in part upon the extent of geothermal development.

2.11.2.4 Cumulative Land Use Impacts of Navy and BLM Programs

Because many land uses of the two programs would be shared or would involve similar existing land uses in a comparable timeframe, the cumulative impacts would be minimized. The new land use impacts would be similar for both programs, and would be a function of the degree of resource development. The degree of cumulative impact can be calculated by multiplying the full-development proposed action impacts shown in Table 2.11.2-1 by 120 percent (such cumulative impacts would have little or insignificant total additional effects on land use.

The significant land use impacts identified and discussed in this section are not all necessarily negative or undesirable. For example, it is quite possible that the people of Inyo County and the residents of Rose Valley would encourage and welcome growth, economic stimulus, and resultant land use changes brought about by even the worst-case impacts discussed above.

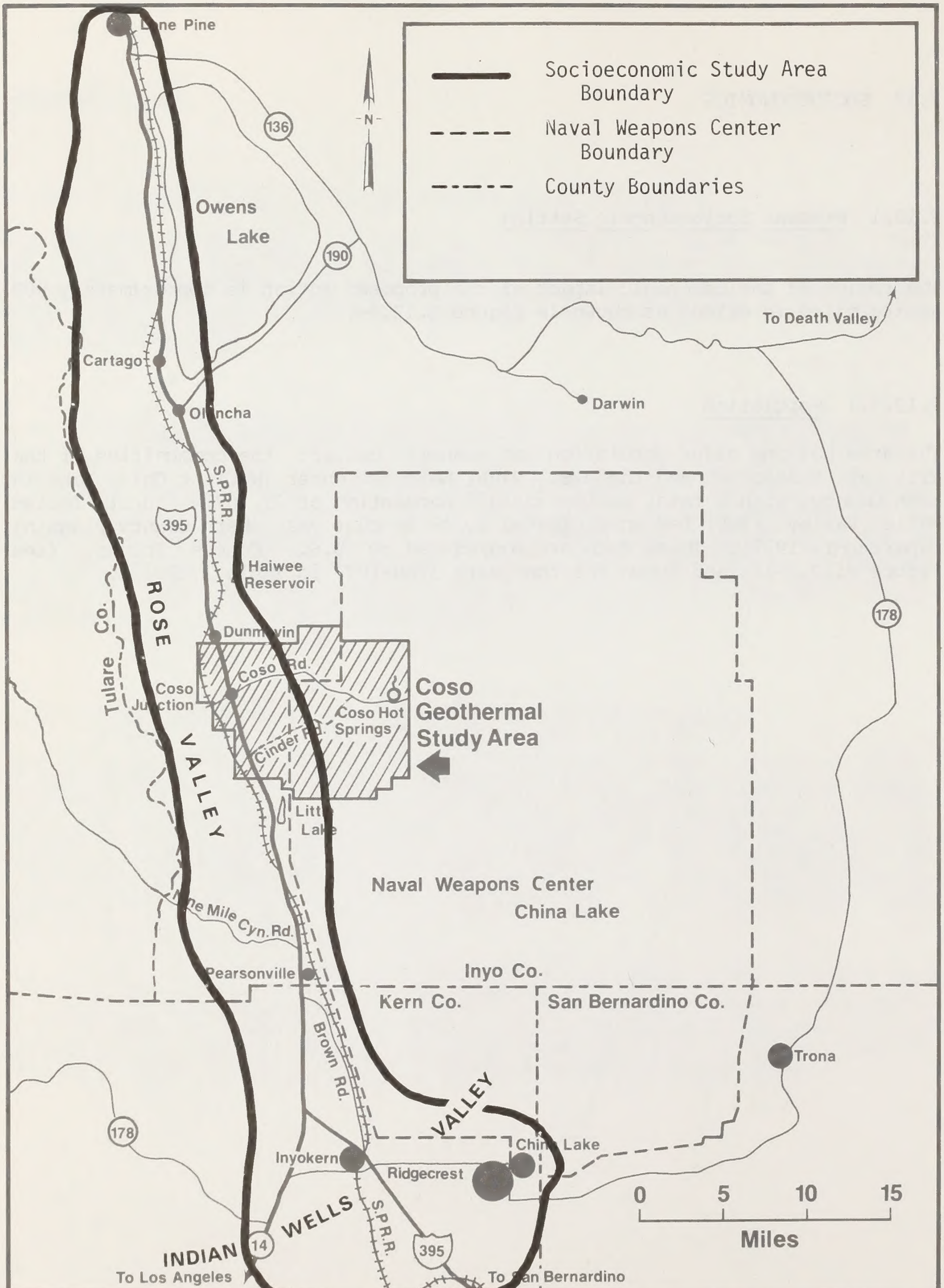
2.12 SOCIOECONOMICS

2.12.1 Present Socioeconomic Setting

The region of socioeconomic impact of the proposed action is approximately 900 square miles in extent as shown in Figure 2.12.1-1.

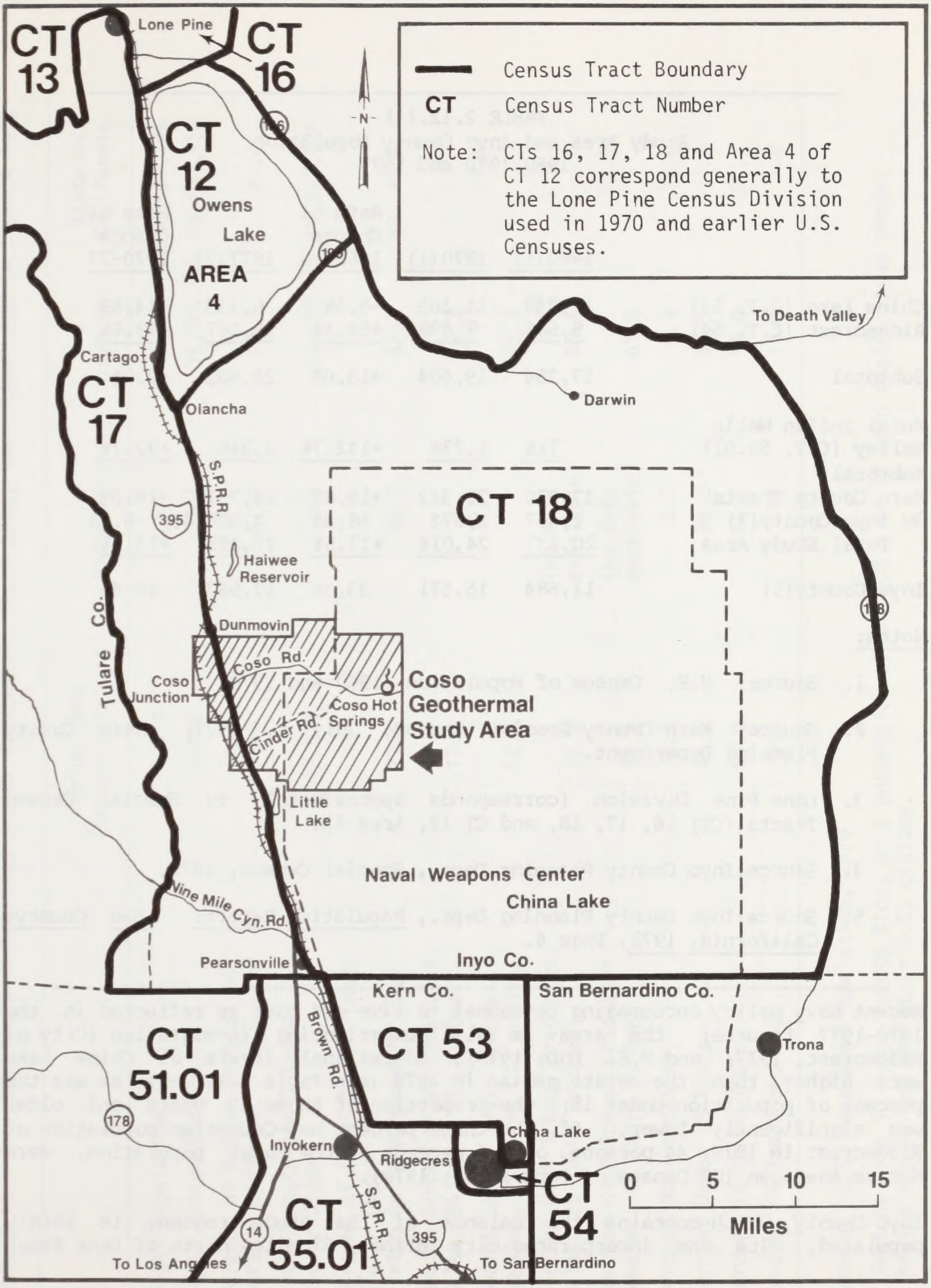
2.12.1.1 Population

The area has one major population and economic center: the communities of the City of Ridgecrest and the U.S. Naval Weapons Center (NWC) at China Lake in Kern County, with a total estimated 1977 population of 21,402; rural Indian Wells Valley (IWV) had an estimated 3,349 in that year (Kern County Planning Department, 1977). These data are aggregated by U.S. Census Tracts, (see Figure 2.12.1-2), and shown for the years 1960-1977 in Table 2.12.1-1.



SOCIOECONOMIC STUDY REGION AND GEOGRAPHIC REFERENCES

Figure 2.12.1-1



CENSUS TRACTS: SOCIOECONOMIC STUDY AREA

Figure 2.12.1-2

TABLE 2.12.1-1
Study Area and Inyo County Population
1960,1970 and 1977

	1960 (1)	1970 (1)	Rate of Change 1960-70	1977 (2)	Rate of Change 1970-77
China Lake (C.T. 53)	11,748	11,105	-5.5%	6,135	-44.8%
Ridgecrest (C.T. 54)	5,506	8,499	+54.4%	15,267	+79.6%
Subtotal	17,254	19,604	+13.6%	21,402	+9.2%
Rural Indian Wells Valley (C.T. 55.01)	716	1,738	+142.7%	3,349	+92.7%
Subtotal:					
Kern County Tracts	17,970	21,342	+18.8%	24,751	+16.0%
SW Inyo County(3)	2,467	2,672	+8.3%	2,508 (4)	-6.1%
Total Study Area	20,437	24,014	+17.5%	27,259	+13.5%
Inyo County(5)	11,684	15,571	33.3%	17,967	15.4%

Notes:

1. Source: U.S. Census of Population (1960 and 1970)
2. Source: Kern County Special Census, July 1, 1977; Kern County Planning Department.
3. Lone Pine Division (corresponds approximately to Special Census Tracts (CT) 16, 17, 18, and CT 12, Area 4).
4. Source:Inyo County Planning Dept., Special Census, 1977.
5. Source:Inyo County Planning Dept., Population Report: Inyo County, California, 1978, Page 4.

Recent Navy policy encouraging personnel to live off base is reflected in the 1970-1977 figures; the area is also experiencing in-migration (City of Ridgecrest, 1977; and U.S. DoD, 1979). Educational levels at China Lake were higher than the state median in 1970 (see Table 2.12.1-2), as was the percent of population under 18; the proportion of those 65 years and older was significantly lower. Of the three percent non-Caucasian population of Ridgecrest in 1970, 44 persons, or 0.6 percent of the total population, were Native American (US Census of Population, 1970).

Inyo County, which contains the balance of the study region, is thinly populated. Its one incorporated city (Bishop, 57 miles north of Lone Pine)

Table 2.12.1-2. POPULATION CHARACTERISTICS OF RIDGECREST, CHINA LAKE, INYO COUNTY AND CALIFORNIA 1970

	China Lake (Unincorporated)	Ridgecrest	Inyo Co.	State of California
Total Population	11,114	7,629	15,571	19,953,134
Total Native Population	10,808	7,504	15,161	18,199,314
Percent of Native Population Born in Different	57.9	57.0	42.7	47.4
Total Population 5 Years Old or Older	10,077	6,924	14,462	18,317,974
Percent of Population 5 Years Old or Over Living in Same House in 1965	27.6	38.3	42.1	43. 43.5
Median School Years Completed, Males, 25 Years Old or Over	13.8	12.4	12.3	12.4
Median School Years Completed, Females, 25 Years Old or Over	12.6		12.3	
Percent High School Graduates, Males, 25 Years or Over	76.9	(no data available)	58.4	62.7
Percent High School Graduates, Females, 25 Years or Over	74.9	(no data available)	65.0	
Percent Non-Caucasian	5.5	3.0	8.3	10.6
Percent Under 18 Years	40.1	36.3	32.5	33.3
Percent 18 to 64 Years	59.0	57.6	56.0	57.7
Percent 65 Years and Over	0.9	6.1	11.6	9.0

Source: U.S. Census of Population, 1970

* Persons born in U.S., Puerto Rico, or a possession of the U.S.; or if born ouside these areas, having one parent who was a U.S. citizen.

accounted for 23 percent of the County's total population of 15,571 in 1970. The southwestern portion of the County is even more sparsely settled than the north. In 1979, aside from perhaps 100-200 persons scattered in small settlements such as Keeler and Darwin and throughout the Panamint Valley, almost all of the residents within the Lone Pine Division lived with the Socioeconomic study area. Lone Pine and Olancha (with 1,800 and 260 persons, respectively, in 1970) comprise the major communities; other settlements or service areas are Cartago, Dunmovin, Little Lake and Pearsonville. An estimate of the 1979 population for the Inyo County portion of the study region is shown in Table 2.12.1-3.

TABLE 2.12.1-3

Estimated 1979 Population:
Inyo County Portion of Socioeconomic Study Area

Community	Population	Source
Lone Pine	1,750	(Farlander, 1979)
Cartago	105	(Benbrook, 1979)
Olancha/Grant	350-400	(Benbrook, 1979)
Total Rose Valley	30	(ERG estimate, May 1979)
Pearsonville	10	(ERG estimate, May 1979)
Scattered Rural	50	(ERG estimate, May 1979)
Approximate Total, Est.	2,300-2,350	

Note: Eastern Lone Pine U.S. Census Division, and Special Census Tract 13, not included; see Figure 2.12.1-2.

There is out-migration of younger persons, probably due to lack of jobs or higher educational opportunities within the County. In 1977 median age (37 years) and persons 55 years of age and older (31 percent) had risen since 1970 and were above state averages (Inyo County Planning Department, 1978:6).

Native Americans comprised 1,321 or 7.4 percent of the county total in 1977 (Inyo Conty Planning Department, 1977b and 1978). Almost all resided in or near reservations in Bishop (722), Big Pine (194), and Independence (26), outside the study area. Within the study area, 151 resided on or near the reservation at Lone Pine, and only a dozen or so scattered in rural areas (Inyo County Planning Department, 1978: 13,17).

2.12.1.2 Private Land Uses

Within Kern County, land ownership is approximately evenly divided between private and public holdings (see Section 2.11 and USDI, BLM, 1976). Private ownerships are centered around Ridgecrest and the Inyokern portion of Indian

Wells Valley (IWV). The developed parcels, however, display a prevailing "leap frog" pattern. Brown Road, north of Inyokern is undergoing considerable residential development (Ridgecrest, City of,, 1977: 27,28; Burns, 1979). In 1977, land zoned in Ridgecrest was estimated at 38 percent residential, 5 percent commercial, 4 percent industrial/manufacturing, 20 percent public faclities, including recreation, and 33 percent urban reserve, for future development (Ridgecrest, City of; 1977: 28). Future proportions are expected to be similar. No comparable data exist for rural IWV.

Inyo County, the state's second largest county (6,490,240 acres), has only 320,000 acres of taxable land; of which only approximately 123,000 (1.9 percent) acres are in private ownership, (IMAGE, 1974a: 24). Most privately owned parcels in the study area are in or near developed areas along Highway 395, south of Lone Pine, most of these represent combined residential and agricultural uses, with grazing incidental. In recent years, there has been little impetus for new private development, and little opportunity for private land acquisition. Future development in the Rose Valley area would depend on Inyo County, BLM, and NWC policies.

2.12.1.3 Housing Stock

The total numbers of housing units in China Lake and the City of Ridgecrest in recent years are shown in Table 2.12.1-4.

TABLE 2.12.1-4
Housing Units: Ridgecrest and Olancha

	1970		1975	
Community	Total Units	Vacant	Total Units	Vacant
NWC-China Lake	3,156	37	2,835	698
Ridgecrest	3,060	274	4,640	252

Source: City of Ridgecrest. Land Use Committee for South Ridgecrest Area: Community Land Use Study. May 1977.

The transfer of several thousand people from the NWC to Ridgecrest has generated considerable pressure for new housing within the City, as well as for increased capacity of local infrastructure, and has stimulated private development. By late 1979 the total available stock in the City was 6,228 units, and the vacancy rate was 14 percent (872 units), largely as a result surplus Navy housing made avialble to the city (Brummet, 1979). Further housing disposal is being considered by NWC as well as 550 acres of NWC land which could be annexed to the city. Inyokern has also experienced considerable housing growth. Total dwelling units for Census Tract 55.01 were

623 in 1970, with a vacancy factor of 11 percent (U.S. Census of Population, 1970). The number of available units has approximately doubled since that time (Cogswell, 1979).

Housing in Inyo County is less plentiful. In 1977, total units available in the study area portion of the County amounted to 1,337 (see Table 2.12.1-5).

Table 2.12.1-5

HOUSING UNITS; INYO COUNTY PORTION OF STUDY AREA, 1977

Special Census Tract	Units Available	Vacant
12 (Area 4)	102 (1)	25 (1)
16	857 (2)	-- (3)
17	163 (2)	24 (1)
18	215 (2)	72 (1)
Total	1,337	

1. Source: State Department of Finance Special Census 1977, cited in NWC, 1979: 143.
2. Source: Inyo County 1978 Population Report: 15.
3. Data not available.

An unknown number of units reported as vacant are probably unsuitable, being remotely located and lacking electricity or sanitary facilities. Of total dwellings in Inyo County in 1960, 41.8 percent were substandard. (IMAGE, 1974b: 35 ff). Review of local newspapers confirms the observation that single family homes are placed on the market infrequently, and rentals are even more scarce. Little Lake Hotel and a few motels and mobile home parks in the area have occasional vacancies, some for longer-term occupancy. There are a few locations such as Olancha/Cartago and Pearsonville where additional mobile homes could be sited.

2.12.1.4 Infrastructure

Police Protection. The NWC maintains range security patrol while BLM rangers provide law enforcement on BLM lands (NWC, 1979: 145-146). The California Highway Patrol (CHP) has jurisdiction over all State and U.S. Highways in cooperation with the County Sheriffs' Departments and BLM Rangers. The Inyo County Sheriff's office maintains full time personnel in Lone Pine (7) and Olancha (2) (Hazelton, 1979). The Kern County Sheriff's Department has 6 officers and 9 reservers in Ridgecrest (Kern County First Supervisorial District, 1978). NWC's China Lake Police Force of 45 members and the Ridgecrest Police Department (20 members plus reserves) provide additional protection.

Fire Protection. Public lands in the area are protected through cooperation between the Navy (on NWC lands), BLM, U.S. Forest Service, and the California Division of Forestry (Peace, 1977: 115). The Los Angeles Department of Water and Power is responsible for fire protection on its lands in Inyo County. Lone Pine and other Inyo County communities have volunteer protection districts (Sherburne, 1979). Indian Wells Valley is covered by the Kern County Fire Department in Ridgecrest and Inyokern.

Electrical Utility. Both Southern California Edison (SCE) and the Los Angeles Department of Water and Power (LADWP) maintain power lines along Highway 395. SCE provides service south of Olancha, while Lone Pine and Owens Valley are served by LADWP.

Fresh Water Supply. No commercial potable water supply is available in the in the geothermal area. Rose Valley and Olancha residents rely on wells or springs. Domestic and stock consumption in Rose Valley is discussed in Section 2.5.1. LADWP supplies water to Los Angeles-owned and leased lands in Inyo County. Residents in the Lone Pine area are supplied largely by LADWP and the North Lone Pine Water District. Cartago also has a water system (Inyo County Planning Department, 1968: 63). The Indian Wells Valley County Water District (IWVCWD) serves part of the Valley and most of the City of Ridgecrest (Kreiger and Stewart, 1977: I-7); there are also several mutual and private water companies. IWVCWD wells have a total capacity of 8,150,000 gallons per day (GPD); peak demand sometimes exceeds 5,000,000 gallons per day (IWVCWD, 1977; Hamilton, 1979). Water quality is currently good; however, anticipated reversal in the direction of water flow by 1995, due to drawdown, could create problems (Hamilton, 1979; McGuire, 1979). Fire hydrant flwo is inadequate in some areas (Brummett, 1979). Most Inyokern residents obtain water from wells.

Gas Utility. Natural gas is supplied to about half the population of Ridgecrest by Pacific Gas and Electric Company (Strayer, 1979). The remainder of the study area population relies on propane.

Flood Control/Storm Drains. LADWP and Inyo County share the responsibility for flood control in Inyo County (Sherburne, 1979; Kuebler, 1979). The Kern County Water Agency is responsible for directing flood control in Indian Wells Valley watershed; however, the only existing facilities are City of Ridgecrest drainage systems (Inman, 1979; Sorenson, 1979; Boyd, 1979).

Sewage/Wastewater Treatment. Most small communities and all of the rural areas use septic tanks. Lone Pine and Cartago have inadequate sewers (Inyo County Planning Department, 1968: 63; Peace, 1977: 85). Ridgecrest and China Lake have a combined sewer system; the treatment plant has a rated capacity of 820,000 gpd with current usage well below capacity (Boyd, 1979). Inyokern County Sanitation District serves approximately 300 persons with a treatment system designed to handle a maximum of 60,000 gpd; current flow is approximately 30,000 gpd (Webber, 1979).

Solid Waste Disposal. The Class I disposal site closest to the CGSA is located in West Covina, in Los Angeles County. Several Class II-2 sites are located in or near the study area including a private facility east of Lone Pine, with another 28 years' capacity (Goodloe, 1979; Goodman: 1979), and the Kern County-operated Ridgecrest Sanitary Landfill, on BLM lands south of Ridgecrest, which can be used until 1982. BLM approval of expansion for an additional 15-20 years' capacity is being sought (Kennedy, 1979; Colter, 1979). Collection is by private contractors.

Health/Mental Health Systems. Inyo County maintains a medical clinic in Lone Pine (Inyo County Planning Department, 1968: 94). Lone Pine's Southern Invyo Hospital, presently utilized to capacity, serves the southern portion of the county. The Kern County Health Department and the Desert counseling Clinic maintain offices in the City of Ridgecrest, providing care to northeastern Kern County and portions of Inyo County. Ridgecrest Community Hospital, with 86 beds (not fully utilized at present), and Drummond Outpatient Clinic serve the Ridgecrest/Inyokern area.

Education Systems. The Lone Pine Unified School District serves the southwestern portion of Inyo County. The district has two elementary schools, one in Olancha (enrollment 50, capacity 100) and one in Lone Pine (enrollment 280, capacity 310), and a high school and a continuation high school, both in Lone Pine.

The Sierra Sands Unified School District serves the Indian Wells Valley Total enrollment for the eight elementary schools, two junior high schools, high school, continuation high school, and adult education program was approximately 5,200 in the autumn of 1979, 1460 below capacity (Saxton, 1979). Declines in enrollment make new construction unlikely, aside from any replacement to meet earthquake safety standards (Brummett, 1979). Higher education is available at Cerro Coso Community College in Ridgecrest and through extension courses taught at the NWC (Ridgecrest Chamber of Commerce, 1978).

Communications. Continental Telephone Company of California provides telephone services to the area. Local newspapers include: the Daily Independent, (Ridgecrest); the Inyokern Inquirer and the Inyokern News Review; the Inyo Register (Bishop), and the Inyo Independent (Lone Pine). There are several local radio stations, and television reception is augmented by cables.

Recreation. Many opportunities for dispersed (as contrasted with urban organized) recreational activities exist in the region's National Parks, Forests, and Monuments. All BLM-administered lands are generally open to the public for recreational use; and some LADWP lands in Inyo County are also available. Oppurtunities for organized recreation exist at Diaz Lake, two miles south of Lone Pine. A 500-acre State Park is proposed nearby. The county-operated 100-acre Kern Desert Regional Park, Helmer's Park (5.5 acres), the Sgt. John Penney pool, and Navy parks and recreational facilities which are available to Ridgecrest residents. Lack of adequate urban, organized recreational facilities would be a critical problem in Ridgecrest without access to these Navy resources (Brummett, 1979).

Other Community Services. Inyo and Kern Counties provide limited welfare and other social services in the study area. The Inyo County Welfare Department is located in Independence; additional services are provided to Native Americans in the Owens Valley. The Kern County Public Welfare Department has a district office in Ridgecrest (Peace, 1977: 89). Kern and Inyo Counties maintain branch libraries in Ridgecrest and Lone Pine respectively. The NWC China Lake library and Cerro Coso College Library are also open to the public.

2.12.1.5 Traffic and Transportation Systems

The highway and local road system providing access to the CGSA is shown in Section 2.12.2.5 on Figure 2.12.2-1, which also shows annual average daily traffic in 1978. U.S. Route 395, the only north-south artery, is a designated scenic highway. Peak loads of 7,000 vehicles per day or more on Highway 395 were reached during August, 1978, at the height of the tourist traffic. In the study area, the highway is four-lane divided with at-grade intersections; south of the Inyo/Kern County line and north of Dunmovin it is a two-lane undivided roadway.

The local road system in the study area is very limited. The Gill's Station Coso Junction/Sykes Road (here called Coso Road) partially paved east of Highway 395, provides access to the Coso Hot Springs area. Cinder Road, unpaved, branches off Highway 395 south of Red Hill; this is said to be the historical route to Coso Hot Springs. With the exception of a portion of Coso Road, roads in the CGSA are unpaved, and are graded on an as-needed basis. Some are one-way, have steep grades, uneven surfaces, sharp turns, dips and narrow widths. Traffic volume is often less than 20 round trips per day, though Coso Road may be used by as many as 25 vehicles during visits by Native American groups to Coso Hot Springs (NWC, 1979: 148).

Regional highways experience high recreational traffic during May through October, particularly on weekends. In winter months weekend recreational traffic is also very heavy. Truck traffic is heavy, particularly on US 395 and State Route 178. Most truck traffic is interregional, especially through the study area where population is extremely sparse.

Rail Transportation. Southern Pacific Railroad maintains a line from Southern California to Lone Pine, running roughly parallel to Highway 395 and provides transportation for lumber and mineral ores to the south. A siding located at Coso Junction could provide service to the leasing area via truck connections over Sykes Road/Coso Road. Presently there are two or theree round trips per week to Lone Pine (freight service only), during summer; winter service is less frequent. Since the Louisiana Pacific Lumber Mill near Pearsonville may leave the area, the railroad, in March 1979, has indicated that it may abandon the line from Lone Pine to Pearsonville in three years.

Public Transportation. Only limited service is available. Inyo County provides some mini-bus service for the elderly and handicapped. Greyhound Bus has two scheduled round trips daily over U.S. Route 395 and makes stops at Little Lake, Olancha, Lone Pine, Independence, Big Pine, and Bishop.

Air Transportation. The air space over the Naval Weapons Center is controlled by the NWC for testing purposes during normal office hours on weekdays. Outside these periods, air space is controlled by FAA. At present, the only regular, commercial air passenger line operating in Inyo County serves Bishop Airport. Bishop Airport also has two charter service; Lone Pine has one. Schedule service from Inyokern Airport is provided by Golden West Airlines (to Palmdale and LAX and C&M Airlines (to LAX).

2.12.1.6 Employment

Employment by sector for Inyo and Kern Counties and Ridgecrest is shown in Table 2.12.1-6 Resource industries, government, and trade are the dominant sectors. Unemployment (shown in Table 2.12.1-7 has generally been lower in Ridgecrest than Kern County as a whole, or in Inyo County. Ridgecrest's high government sector employment makes it more directly sensitive to Federal budgetary fluctuations than to business cycle influences. In general, however, the economy of the China Lake/Ridgecrest area has been stable; employment at NWC ranged between 4,000 and 4,600 (approximately) in the years 1970-1976. Further expansion of some RDT&E activities at the base may be anticipated (NWC, 1977b: 45).

Research, Development, Testing & Evaluation?

TABLE 2.12.1-6
Employment by Sector: 1970 and 1977

	Inyo County 1970 (1)	Inyo County 1977 (2)	Kern County 1970 (1)	Kern County 1977 (3)	Ridgecrest 1970 (1)
Agriculture, Forestry Mining	891	691	20,565	36,000	250
Construction	593	339	7,121	5,300	163
Manufacturing	235	97	8,353	8,600	145
Transportation, Communication & Utilities	671	672	7,615	6,700	239
Trade	1,345	1,121	23,738	29,200	642
Finance, Real Estate & Insurance	158	221	4,210	4,200	271
Services	1,732	1,588	27,877	18,500	562
Government	326	1,439	10,061	31,600	1,004
Other	-----	-----	-----	8,500	-----
TOTAL	5,951	6,168	109,539	148,600	3,276

NOTES:

1. U.S. Census of Population, 1970
2. Inyo County Planning Dept., Population Report, Inyo County, California, 1978: 9.
3. California Employment Development Dept., Annual Planning Information, Bakersfield SMSA, May 1979: 6-7.

TABLE 2.12.1-7
Labor Force and Unemployment

	Inyo County 1970 (1)	Inyo County 1977 (2)	Kern County 1970 (1)	Kern County 1977 (3)	Ridgecrest 1970 (1)
Civilian Labor Force	6,292	9,225	117,390	163,000	3,435
Unemployment	341	950	7,851	14,400	159
Unemployment Rate	5.4%	10.2%	6.7%	8.8%	4.6%

NOTES

1. U.S. Census of Population, 1970
2. California Employment Development Division, Bishop Office, Aug. 29, 79, personal communication.
3. California Employment Development Dept., Annual Planning. BAkersfield SMSA, May 1979: 6.

2.12.1.7 Income

Income data for California, Inyo and Kern Counties, and Ridgecrest are included in Table 2.12.1-8.

TABLE 2.12.1-8
Study Area Income Levels

		Inyo County	Kern County	Ridgecrest	California
Median Family Income	1969	$ 9,964	$ 8,937	$11,009	$10,732
	1977	$11,687	$10,936	$16,077	-
Per Capita Income	1969	$ 3,436	$ 2,823	$ 3,866	$ 3,614
	1977	$ 4,756 (1)	$ 3,732	$ 5,392	$ 5,464 (2)

(1) NWC, FEIS for the Navy Coso Geothermical Development Program, 1979: 142).

(2) As of July 1979, the most recent statistics available from the Department of Commerce.

All the areas, including the state, have lost real purchasing power as measured by the National Consumer Price Index, which rose 65 percent in the 1969-1977 period. By contrast, per capita incomes rose by only about 50 percent for the state and 30 to 40 percent for the other three areas.

2.12.1.8 Major Industry

Inyo County Area. The key industrial activities in Inyo County are recreation, mining, and livestock and agriculture. Within the study area are a cinder mine (at Red Hill), stone, sand and gravel, and clay mines, three pumice mines, and some tungsten and uranium exploration.

A shift in Inyo County away from agriculture towards livestock production--largely due to shortages of available land and water-- is reflected in total production values for 1978: $1.3 million for corps (down 13% from 1977) and $3.8 for livestock (up 81% over 1977; however annual range cattle production figures fluctuate widely). Grazing activity is discussed in Section 2.11. Future agricultural development will depend on the reliable supply of irrigation water, availability of arable land, and the introduction of less water-intensive and more salt-tolerant crops (USDI, BLM, 1978b: Ch.IV; Inyo-Mono Counties Department of Agriculture, 1979:3).

Recreational resources are extensive, are largly available all year round, and are used by people from throughout California (Angelo, February, 1979). Although Inyo County campgrounds reportedly served approximately 250,000 people in 1978, the County estimates the actual number of visitors at five to ten times the reported figure (Angelo, February 1979). An estimated 80 percent of the County's economy is dependent in some manner on tourism and recreation (Angelo, February 1979); and the annual growth of that industry is projected at 1.5 percent, assuming gasoline availability.

Kern County Area. Industrial activity in the Ridgecrest and Inyokern areas largely supports the NWC's efforts in research, development, testing and evaluation of advanced weaponry. A number of computer and electronics firms are located in Ridgecrest, as well as two complete machine shops. A major national trucking company is locating a large terminal in the Indian Wells Valley (Ridgecrest Daily Independent, March 23, 1979). The area is becoming a regional service center for motorcyclists and other recreational vehicles (Brummett, February 1979), and agriculture is gaining in importance. East of Ridgecrest in San Bernardino County are Stouffer Chemical Company and Kerr-McGee Chemical Company, outside the study area but providing additional stimulus to the economy of northeast Kern County.

2.12.1.9 Public Revenues

A summary of general public revenue sources in Fiscal Year 1977-78 for Inyo and Kern Counties, as well as for the City of Ridgecrest, is presented in Table 2.12.1-9.

Revenues form property taxes are a function of both assessed valuation (25% of full market value) and property tax rate. The Jarvis-Gann Property Tax Reduction initiative, approved by California voters in June 1978, has had a substantial impact upon property tax rates and the tax bases. In effect, it limits property taxes to one percent of the "full cash value", (assessed valuation as recorded by the County Assessor in 1975-76 or, thereafter, the appraised value of the property when purchased or newly constructed), as opposed to previous rates of three to four percent. The value of this tax base may be increased to reflect an annual inflation rate not to exceed 2 percent annually. Net total assessed value in fiscal year 1978-79 was approximately $129.5 million for Inyo County, $2,848.4 million for Kern County, and $42.8 million for the City of Ridgecrest.

California levies a six percent sales tax on local purchases excluding sales of food for home consumption and prescription medicines. One percent (one sixth) is returned to the County or community. The state also levies a six percent use tax on materials purchased out of state, and provides for a one-sixth return to the area which is the point of destination (State of California, Board of Equalization, 1977b). Total taxable sales in 1977 were approximately $87.8 million for Inyo County, $1,933.2 million for Kern County and $6.3 million for the City of Ridgecrest.

Table 2.12.1-9
Summary of General Revenues: Fiscal Year 1977-78
(in thousands)

Area	Taxes	Licences & Licences	Fines/ Penalties	Use of Money/ Properties	From Other Agencies#	Current Service Charges	Other Revenue	Total
Inyo County	4,024.0	129.3	153.2	173.3	4,423.0	1,748.7	154.4	10,805
Kern County	90,104.2	1,453.6	2,111.9	7,170.7	68,778.5	27,657.5	(3,125.7)	194,150
City of Ridgecrest	1,364.2	147.7	45.2	975.5	1,748.7	91.7		4,410

Includes funds received by these counties from BLM under PL 94-565, Payment in Lieu of Taxes Act, of 1976. For FY 1977-78 these payments amounted to approximately $493,000 and $515,000 to Inyo and Kern Counties, respectively.

Sources: State of California, Controllers Office, Annual Report: Financial Transactions of Cities, 1977-78; and, Annual Report: Financial Transactions of Counties, 1977-78.

Table 2.12.1-10
Summary of General Expenditures: Fiscal Year 1977-78
(in thousands)

Area	General Government	Public Safety	Public Works	Health and Sanitation Services	Culture and Recreation	Public Assistance	Public Education	Debt Service	total
	Category of Services								
Inyo County	3,262.5	2,110.4	1,591.8	1,908.3	307.3	1,592.8	176.6	--	10,950
Kern County	23,498.3	48,739.3	13,745.3	31,737.6	5,112.5	56,615.5	2,740.3	325.3	182,514
City of Ridgecrest	481.7	950.5	3,073.8	--	195.6	--	--	--	4,701

Sources: State of California Controller's Office, Annual Report: Finanacial Transactions of Cities, 1977-78; and Annual Report: Financial Transactions of Counties, 1977-78.

2.12.1.10 Public Expenditures

A summary of general expenditures for Fiscal Year 1977-78 for Inyo and Kern Counties as well as for the City of Ridgecrest, is presented in Table 2.12.1-10.

2.12.1.11 Electricity Supply and Demand

Prior to the impacts of the 1973 OPEC oil embargo, US electricity demand grew by about 7% annually; in 1974, usage actually declined. It is now increasing and future growth is projected at 4 to 5 percent annually. Recent OPEC price increases may reduce the growth rate to the extent that electricity production depends upon oil.

National tredns hold true for California. Pre-embargo rates were 7 to 9 percent; since 1974, rates have been 3 to 5 percent. The study performed for the ES assumes annual growth rate of 4.1 percent for California electricity sales and 4.0 percent for growth of peak demand (See Appendix G). Such growth in peak demand would require doubling of generating capacity from 38,000 MW in 1977 to 73,200 MW in 1995.

Of the electricity used in California in 1977 (including 17 percent generated outside the state), 72 percent was generated by gas- and oil-powered plants. The remainder was generated from coal (10 percent), and from nuclear, geothermal and hydroelectric plants (5, 6, and 7 percent, respectively). Dependence on oil- and gas-powered generation should decrease due to the cost of these fuels and to legislation requiring that electric utilities phase out gas- and oil-powered generating facilities by 1990 (2000 under certain conditions).

At present, coal, nuclear, and vapor-dominated geothermal power plants all have approximately the same generating costs ($20-30 per MWH including annualized capital costs). Liquid- and brine-dominated geothermal fields have generating costs up to $40 per MWH. Improved technology (as well as costs of other fuels) should make liquid-dominated geothermal operations cost competitive in the 1990s.

2.12.1.12 Public Attitudes

A synopsis of local public opinion concerning regional growth and the proposed development, was compiled from local newspapers, informal personal contacts, and review of environmental studies performed for other proposed developments in the region. Opinion surveys were reviewed for social values and attitudes expressed by desert residents (USDI BLM, Bakersfield 1977; Field Research Corporation, 1977; and USDI BLM, 1978a and b). The scope of the present study specifically precluded the use of questionnaires or other formal interview techniques.

Review of these sources confirms that the majority of desert residents over the age of 18 moved to the desert from other regions, many for reasons of health, retirement, job transfer or military assignment, and that the desert environment is perceived as contributing to their well-being. Independence, privacy, recreational opportunities, and aesthetic qualities are all perceived as integral and highly valued aspects of that environment.

In the Ridgecrest/Inyokern area, perception of the proposed development seems generally positive. Those who express any opinion seem to assume that the program will be implemented and that it will generally benefit the region (Bottorff, 1979). However, any additional rapid growth in Ridgecrest is perceived as presenting problems for the city's infrastructure (US DOD, 1979: D-6). Problems with water delivery and a general lack of services are also seen as constraints to further development in the greater IWV area (ibid.: D-4; Inyokern News-Review, April-August 1979).

Residents of the Inyo County portion of the study area generally perceive that region's economy as being static. Population decline is seen as likely to continue (Farlander, 1979); and anxiety has been expressed regarding the future of recreation and tourism--the area's economic staple--as a result of fuel unavailability and high price. Availability of land is an additional concern (Lane, 1979). Opinion in the southern portion of the county generally favors growth (Budlong, 1979), and the proposed development is considered in a positive light. Ambivalence is expressed, however, by residents who treasure the existing qualities of life in the area; for example, the loss of a sense of privacy is seen as a negative though necessary outcome of any major development program (Hennis, 1979). In general, these residents appear to perceive a necessity for some substantial broadening of the economic base, even while they regret the changes this would bring. Opinion within the county as a whole on the subject of growth is divided. In the Bishop area, where a vocal segment of the public has expressed opposition to growth, a local property owners' association obtained a temporary injunction to halt all construction within the county pending the complete revision of the county's General Plan (Inyo Independent and Inyo County Newsletter, June-September 1979).

In general, countywide opinion seems to support a continuation and enrichment of present lifestyles and values. In the southern Inyo study region, this support is no less observable than elsewhere, but here the residents express an acceptance of the need for industrial infusion, as long as environmental values are preserved.

2.12.1.13 Native American Concerns

Approximately 1300 Paiute-Shoshone and Northern Paiute Indians live in Inyo County most of them in or near one of the four reservations at Bishop, Big Pine, Fort Independence, and Lone Pine. Though all but the Lone Pine reservation are outside the defined socioeconomic study area, these groups have all expressed similar concerns over the proposed development, and for purposes of this study they, and the Kern Valley Indian groups, are considered as one group. Their concerns have been publicized in local and regional news media and have been the subject of several studies such as those by Theodoratus and Madsen (1977), Johnson (1977), and Iroquois Research Institute (NWS, 1979b).

The anxieties expressed by local Indian groups have centered around four issues: (1) impacts of geothermal development upon the temperature, flow, and other characteristics of the waters or muds at Coso Hot Springs; (2) disturbance, either deliberate (vandalism) or accidental, of archaeological resources -- and particularly burial sites; (3) difficulties with regard to access to the Springs and a nearby Prayer Site for medicinal and religious purposes; and (4) once access may have been gained, the prospect of having their ceremonies interrupted by traffic, noise, or the presence of workmen.

There is evidence that Paiute-Shoshone peoples traditionally frequented the Springs, and that they attributed medicinal values to the waters and muds (NWC, 1979b: 6). Many local Native Americans attest to this and also to the religious significance of the area for their ancestors, citing creation myths and other folklore connected with the Springs (ibid.: 189, ff.) and giving personal recollections of trips made there for religious rituals and for use of the healing muds (Johnson, 1977: 8-10). Many who were contacted during the present study mentioned these visits.

This traditional use was constrained by development of a commercial spa at Coso Hot Springs in the early 20th Century, and in 1943 by the withdrawal of the area from public use as part of the NWC. In intervening years the Navy has, when possible, accommodated Native American groups wishing to visit the site; however, it is clear that unrestricted access is incompatible with the NWC mission. A Coso Ad Hoc Committee, comprising representatives of the Owens Valley and Kern Valley tribes, was formed in 1977 to provide for communication and negotiation with NWC. Recently, an agreement has been reached between the Navy and Owens Valley Paiute-Shoshone Indians, guaranteeing eight scheduled overnight visits per year (and additional visits on request) during which Indians will have exclusive use of the area immediately surrounding the Springs and Prayer Site (Inyo Independent, August 2, 1979). It should be noted that according to some medicine men, there may be more than one prayer site. Inclusion of the Springs and Prayer Site on the National Register, and listing and nomination of other nearby sites, attest to the cultural significance of the area.

In view of the importance of this issue, and the rich archaeological deposits in the area (see Section 2.10), the archaeological survey performed for this study was undertaken in coordination with local Native Americans. The Coso Ad Hoc Committee was contacted prior to the survey, and three members of the local Indian community acted as monitors during the entire survey. A number of other tribal members from all four reservations were contacted by letter, phone, or personal meeting by members of the Socioeconomics and Land Use study teams. One member of the team was invited to visit the Tribal Elders of the Owens Valley at a luncheon at the Bishop Reservation and heard several elders state their concerns. In addition to these contacts, literature and local newspapers have been reviewed. It is hoped that the following accurately summarizes the feelings expressed.

It is difficult for members of Western civilizations to comprehend the traditional Indian view of the earth as universal life-giver and healer, and equally difficult for traditional Indians to grasp the prevailing civilization's view of land as something that can be bought and sold by private or public entities. This is only one instance of the wide divergence in value systems. Many of today's Native Americans have bridged the gap and can participate in both value systems to some extent; but this is an effort, and they feel it is an effort few Anglo- Americans are willing to make. For most of the elders, Western values are seen as an imposition of the majority upon the minority, which they accept with resignation. Acceptance has frequently led to structural weakness in the traditional fabric, and to ideological conflicts among the younger members of the tribes (USDI BLM, Bakersfield, 1977:112). The recent resurgence of Native American traditions, and the legal recognition beginning to be accorded them (see, for example, the American Indian Religious Freedom Act of 1978, briefly discussed in Appendix A), have not yet healed these divisions.

The anxieties expressed over geothermal development near Coso Hot Springs should be viewed against this background. The Owens Valley elders and spokesmen feel that the Springs, the Prayer Site, the petroglyphs, and perhaps unknown burial sites have already been taken away from them. The guarantee of eight scheduled visits per year (even if crisis visits for healing are permitted on occasion) seems a far cry from their recollections. One member of the Owens Valley tribes believes that several hundred would visit the Springs if freely permitted; another, equally knowledgeable, estimated "a couple of thousand," including Indians from outside Inyo County. The unease over possible alteration of the Springs persists, and in fact not enough is known to predict impact with any certainty (see Section 2.5). The concern over disturbance of burials is accentuated by the fact that locations of interment sites within CGSA are not well known. Tribal elders have agreed to assist NWC personnel in locating any sites known to them so that protective measures may be taken (NWC, 1979a:159). Other measures suggested by the Paiute Warriors' Association and the Elders include protection of petroglyphs in the region by Indian patrols (USDI BLM Bakersfield, 1977: 82). Several Elders have stated that the Prayer Site is on both sides of Coso Road, and that the National Register boundary may not include all of the area used.

These areas of concern are discussed under Hydrology, Land Use, Traffic, Noise, Cultural Resources, and Socioeconomics.

It is the feeling of researchers that many of the Native Americans are resigned to the proposed development. They feel the recent access agreement is not ideal but "it is something." They hope that the government will respect their values as members of a plural society, will give their cultural and archaeological resources all possible protection, and will give their people a prominent voice in planning multiple uses of public lands. These views, however, are not necessarily those of all, or of the younger, members of these tribes.

2.12.2 Impacts of the Proposed Action on Socioeconomics

The following analysis emphasizes full development of 550 MW on BLM-leased lands. However, since the extent of the geothermal resource is not well understood (see Appendix B), and since legal constraints and high costs may deter development, a lower level of development is also analyzed, and is considered the most likely: approximately 250 MW on BLM-leased lands (and 10-15 MW on NWC lands), with development taking place more spasmodically over fewer years than as described in Chapter 1.

Employment Levels. Conservatively high average employment estimates for full development (550 MW) are shown in Chapter 1 Employment estimates would be lower if economies of scale could be effected through unitization of BLM leases; however, unitization is not assumed here (see Chapter 8). For assessment of greatest potential impact, employees are assumed to come from outside the study area. One 50-MW plant would be coming on line approximately every two years after 1985, and construction employment would be essentially continuous until 2010. There would be active exploration/drilling in all zones. Average employment during development/operation (45 years) is estimated at 375, rising to approximately 500 during a 10-year period (2001-2010). In the lower-level development scenario (250 MW), average employment is estimated at 190, with occasional peaks at about 300. Construction would be intermittent and construction employees would be temporary. Exploration/drilling, operation, plant workover and road maintenance could require essentially full-time employment. During startup (approximately four years), an average work force of 67 is assumed in both scenarios, and during final closeout (two years), a force of 50.

Housing Assumptions. During the start-up years, until the field potential is better known, workers would seek temporary housing, many in the Ridgecrest area but some in southern Inyo, near Olancha or at Little Lake Hotel. The close-out crew of about 50 would probably have a similar residence pattern. For the 45-year development period, the following assumptions apply.

Short-term drilling and construction employment frequently attract transient workers, content with temporary lodgings of a less than optimal nature. In full field development, with likelihood of essentially permanent, full-time employment over a number of years, the probability of employee relocation to the northeastern Kern/southern Inyo region increases. If an average of 375 employees eventually relocated to the study region with families (conservatively assuming an average family size of three persons), maximum population increase would be 1,050; during the 10-year period when employment could increase to approximately 500, the total new population including families could be 1,500. It is this most extreme case which is examined in the following subsections. It must be emphasized that, even with long-term employment for 375 to 500 workers, certainly not all will be married, have children, and decide to relocate their families; the analysis is performed to determine the capacity of the region to absorb the maximum possible impact.

No developer-supplied housing is assumed in the project description. Families will be assumed to locate mainly in the IWV area but with a scattering throughout southern Inyo as far north as Lone Pine and a few in remote locations. For estimating most severe impact, however, the analysis assumes a concentration of 500 new· families in one area, either the Ridgecrest/Inyokern/Brown Road area or, most extreme of all, southern Inyo County (Olancha/Cartago or Rose Valley). This last case is considered highly unlikely, but the possibility is examined. The lower-level development scenario, involves approximately half the above number of employees; many of these would be temporary. In this case, permanent employees and families would probably live in the Ridgecrest area at first, with spillover into Inyokern/Brown Road as housing becomes available, and a scattering in southern Inyo County. These housing assumptions are summarized in Table 2.12.2-1.

2.12.2.1 Population

In the maximum development case, with all employees and families living in Ridgecrest, project-related growth could constitute 5.5 percent of the City's total population and 4.2 percent of the total Indian Wells Valley (IWV) population by the year 2000; see Table 2.12.2-2. Concentrations of all employee families in southern Inyo County (in the western portion of Lone Pine Census Division) would account for approximately 20 percent of the entire Division's projected population in the years 1990-2010. Population characteristics of both areas would be altered by this imported population. Employee families would be in their productive years; young children might lower the median age. Impact on ethnic composition, education levels, and life styles would be difficult to estimate at this stage. The average level of education attained by the imported families may more nearly approach the state level than the average in China Lake in 1970. An increasing number of wives of employees may seek employment in the area, in keeping with national and state trends (USDI, BLM, 1978a: III-4); many of these jobs would probably be in the service industries. In addition to employees, approximately 300 indirect jobs would be created in the study area by the proposed action; see Section 2.12.2.6. It is expected these jobs would be filled mainly by local residents, including wives of geothermal employees. In the lower-level development case, approximately half of the maximum employment is expected; and a higher proportion would be temporary, as development would

Table 2.12.2-1 EMPLOYMENT/HOUSING SCENARIOS EXAMINED IN SOCIOECONOMIC ANALYSIS

Employment/ Housing Scenario	BLM Leasing Development Scenario	Average/Peak Employment (Maximum new Population)	Residential Pattern Anticipated
Lower Level	Most Likely (250 MW)	190/300 (570)	Ridgecrest at first; eventual spillovers and scattering into Inyo County.
Greatest Impact	Full Field Development (550 MW)	375/500 (1050, growing to possibly 1500 in years 2000-2010)	100% in Ridgecrest/ Inyokern/Brown Road, or 100% in one Location in sourthern Inyo County.

TABLE 2.12.2-2

POPULATION IMPACTS OF PROPOSED ACTION: 1980-2030 (ASSUMING 600-MW DEVELOPMENT AND CONCENTRATION OF EMPLOYEES AND FAMILIES IN ALTERNATE LOCATIONS)

	1980	1990	2000	2010	2020	2030
POSSIBLE MAXIMUM POPULATION RESULTING FROM PROPOSED ACTION (EMPLOYEES AND FAMILIES)		1,060	1,450	1,500	900	350
Ridgecrest/China Lake Population [1]						
Without Project:	21,900	24,200	26,500	29,300	32,300	35,700
With Project:		25,260	27,950	30,800	33,200	36,050
Project Population as % of Total:		4.2%	5.5%	4.7%	2.7%	1.0%
Total Indian Well Valley (IWV) Population [1,2]						
Without Project:	25,700	29,100	33,000	36,500	40,300	44,500
With Project:		30,160	34,450	38,000	41,200	44,850
Project Population as % of Total:		3.5%	4.2%	4.0%	2.2%	0.8%
Lone Pine Census Division Population [3]						
Without Project:	3,300	4,330	5,230	6,100	6,950	7.900
With Project:		5,390	6,680	7,600	7,850	8,250
Project Population as % of Total:		19.7%	21.7%	19.7%	11.5%	4.3%

1. Source: 1980-200 projections from Kern County Planning Department, Population by Census Tract, March 1979; 2010-2030 profections based on Kern County Planning staff population prijections for 2000 using a growth rate of 1% (J. Folpmers, Kern County Planning Department, May 1979)

2. Figures include Ridgecrest/China Lake.

3. Projections for Lone Pine Division estimated as 25% of Inyo County's projected growth 1980-2030; discussed with R. DeHart, Inyo County Planning Department May 1979. (See Figure 2.12.1-1 for boundaries of Lone Pine Census Division.)

be intermittent.

Temporary employment as a result of NWC geothermal development is estimated at a maximum of 350 during the years 1980-1984 (NWC, 1979). During this period the BLM-proposed program would employ only about 67 persons. Maximum permanent population increase due to the NWC installation would be 175 persons after 1985.

2.12.2.2 Private Land Uses

The program would have an indirect impact in the socioeconomic study area by generating a need for additional private land uses: residential, commercial, public facilities and recreational. A conservatively high estimate of 0.5 acres per permanent worker's family, for all private land uses, is assumed (USDI, BLM, 1978: 1238). Private land use requirements during the start-up and shutdown periods are expected to be minimal. If existing temporary housing is used, there would be virtually no additional requirements.

An influx of 375 families could require approximately 188 acres of private land, more could be required in the years 2000-2010. The Ridgecrest/Inyokern/Brown Road area could probably accommodate this requirement, though land used for this purpose would be unavailable for its present uses (largely grazing, agriculture and open space). Possible future development in southern Inyo County is discussed below and in Section 2.11. In the lower-level development scenario, half (or less) of this requirement would be expected.

No prediction is made concerning private land use requirements for the 55 permanent workers at the NWC geothermal facility (NWC, 1979).

2.12.2.3 Housing Stock

The greatest-impact scenario involves concentration of 375 families, all in Indian Wells Valley (IWV) or all in Rose Valley. The IWV area could probably accommodate all of the new housing requirements. The need would develop over a period of several years. There are presently several hundred vacancies in the total IWV area including Ridgecrest. Available housing in Rose Valley is limited to approximately 25-50 rooms for temporary residence and a few trailer park vacancies. The area would thus require virtually all new housing; 500 units might be required during the period 2000-2010. The lower-level development scenario envisions housing 190 families in IWV with spillover into Inyo County. The private sector could probably accommodate this need. The proposed Kerr-McGee expansion in Trona could create competition in Trona.

During construction of the NWC geothermal facility and startup of the BLM program, 420 temporary dwelling units could be required. Thereafter, the two programs might require a maximum of 550 permanent residences.

2.12.2.4 Infrastructure

Police Protection. Direct impacts involve potential calls for emergency assistance, within the CGSA. The greatest indirect impact would involve housing of 1500 people in Rose Valley or in Olancha/Cartago. Expansion of the Inyo County Sheriff's substation in Olancha (3 additional persons), or establishment of a new substation (5-6 persons) would be required. A similar population increase in IWV could require addition of one officer with equipment and vehicle support.

Fire Protection. Native vegetation on geothermal sites is too sparse to support wildland fires; control rooms would be hardened, with fire suppression equipment on hand. However, if full field development takes place, a fire station may be needed near the CGSA. An added 1500 people living in Rose Valley would require expansion of existing volunteer fire protection in Olancha. The same number of people entering the IWV would cause an increase in the number of calls for fire protection and the possible addition of one person, plus equipment.

Electrical Utility. The only direct electricity requirement would be 8766 mwh/year required for water line pumping. During construction, electricity needs would be met through gasoline-generated power; during operation, power generated through the process would be used. Indirect requirements are estimated at 500 kwh per month per employee family. The greatest impact would occur in Rose Valley, with a possible 500 families using a total of approximately 250,000 kwh/month.

Fresh Water Supply. Consumption by workers and their families is estimated at 220 gpd per person. Present conditions indicate that adequate water will be available although drawdown of groundwater IWV would be accelerated; the IWV County Water District projects importation of water by the year 2020 (Hamilton, 1979). A water district would be necessary formed in Rose Valley if population concentration occurred there.

Gas Utility. There will be no project use of natural gas. Domestic consumption is estimated at 5000 cubic feet per month per dwelling unit (or 850 gallons of propane per year per family).

Flood Control/Storm Drains. Runoff and flood hazard within the CGSA are discussed in Section 2.5.2. Indirect impacts are related to population growth, which results in increased runoff as development reduces the amount of ground surface. In addition, homes and buildings often occupy potentially hazardous sites, such as flood plains and canyons.

Sewage/Wastewater Treatment. During early phases of the program portable sanitary facilities would be used on site. When the size of the work force warrants, fixed disposal facilities would be installed. Indirect impacts would be related to total population increases. The average generation factor in Ridgecrest and other local communities with sewer systems is approximately 100 gallons per capita per day (Greenfield, 1979; Webber, 1979). Ridgecrest Sanitation District's facilities could presently accommodate a 1500 additional residents; however, by the year 2010 the system could be over capacity (Greenfield, 1979). A similar situation exists in Inyokern (Webber, 1979). A concentration of 1500 persons in Rose Valley would require formation of a sewer district there. Existing Cartago and Lone Pine sewer systems would have to be brought up to standard to accommodate any new residents.

Solid Waste Disposal Facilities. Drilling mud, amounting to perhaps 25,000 ft^3 (708 m^3) per well (based on figures projected for wells in the Brawley Field (Imperial County, 1979: 26)) would contain possibly hazardous additives. During operations, an unknown amount of Group I geothermal solid waste would result from cleaning of pipelines, production lines, etc. (up to 2000 metric tons or 1320 m^3 of waste per year is the figure projected for a 10-MW plant at Brawley; Imperial County, 1979: 274). In addition, sludge from the H_2S abatement system could amount to as much as 2 yd^3 (1.5 m^3) per day per 50-MW station (based on figures projected for a 139-MW plant at the Geysers (PG&E), 1975, App. M:3). All of the above would initially have to be hauled to a Class I or Class II-1 site (see Chapter 1). Rock and cuttings from well drilling, if not permeated with drilling muds, would be disposed of in waste sumps at the sites. Inert construction debris would be disposed of by hauling to a Class II-2 or Class III site; the nearest Class II-2 facility at Ridgecrest could presently accommodate this debris. Office-type paper waste generated at the site and domestic rubbish generated by the increased population could also be accommodated by local facilities. The life of these facilities would be incrementally shortened.

Health/Mental Health Systems. The presence of 1500 additional persons would increase demand for health care and related services, including emergency and out-patient treatment at the Southern Inyo Hospital in Lone Pine and the Ridgecrest Community Hospital as well as calls for physicians' services. The proposed development may stimulate additional physicians to move into the area.

Education Systems. Approximately 20 percent of any new permanent population due to geothermal development may be children of school age. In the greatest-impact case, 300 additional students might enter either the Sierra Sands Unified School District or the Lone Pine Unified School District Such an addition in Rose Valley would require expansion of the existing elementary school in Olancha. High school students in Rose Valley would have to be bused to Lone Pine. The additional students could constitute a beneficial impact on the district, as enrollments have been declining in recent years (McCollum, 1979). The Sierra Sands Unified School District is presently below capacity; enrollment has also been declining there. A significant population increase could, however, affect the District's plans regarding replacement or expansion. Some additional enrollment could be expected at Cerro Coso Community College in Ridgecrest.

Communication. Telephone and radio telephone services at geothermal sites can be provided by Continental Telephone Company. The use of microwave links would minimize land disturbance. The need for two-way radio communication may be increased, along with the potential for emergency services.

Recreation. With increased population, some undetermined increase in the area generally (for example, in the number of visitors to nearby National Parks, Forests, and Monuments) is expected.

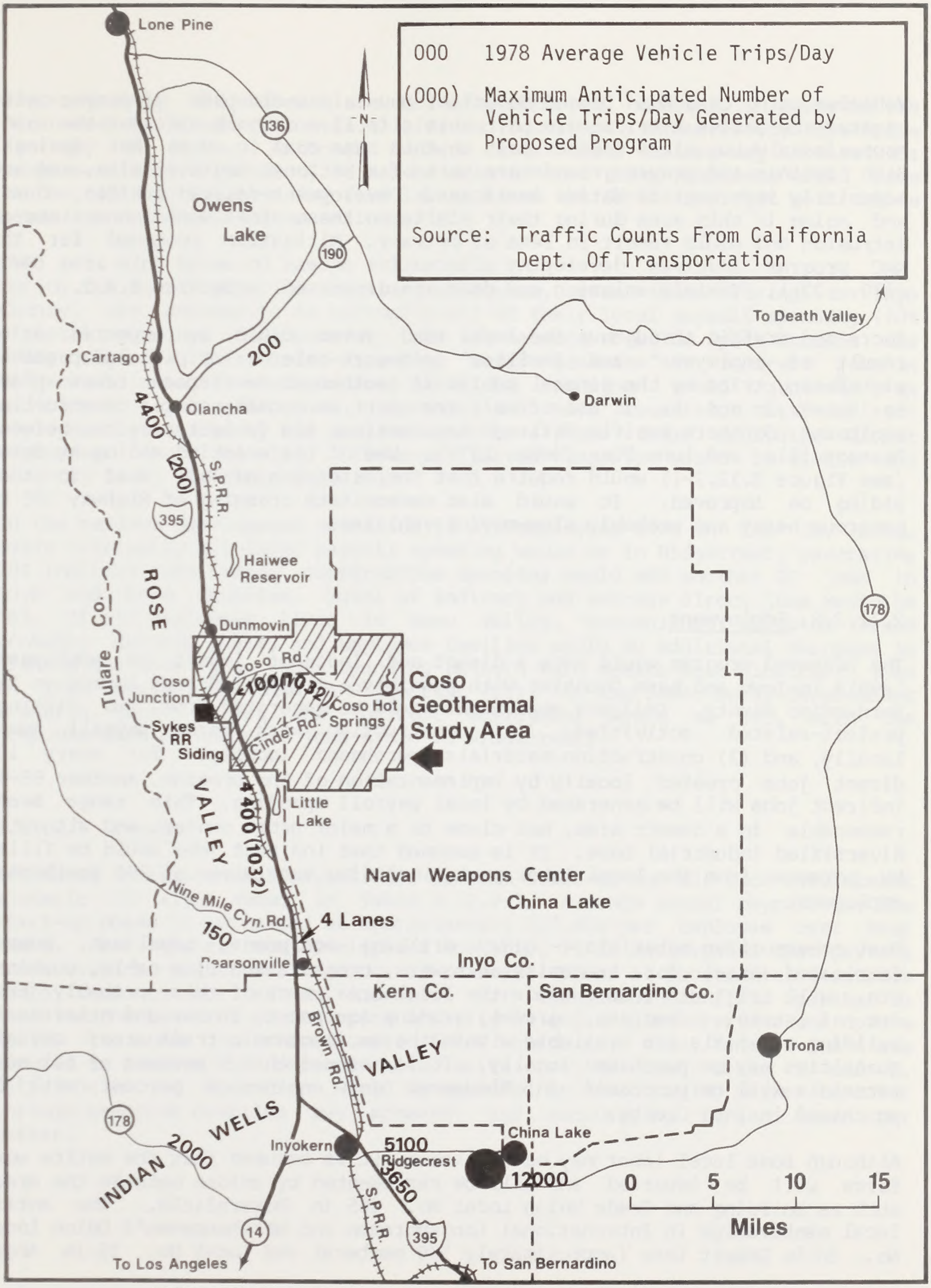
Cumulative Impacts. The cumulative impact on the infrastructure of 350 (maximum, NWC) and 67 (start-up, BLM) temporary workers could be substantial, depending on where those workers reside. After NWC facilities are operational, maximum new permanent population related to that program could be 175, again a potential major impact in a rural area with few existing services.

Geothermal wastes generated by the two programs would be directly related to the extent of geothermal production. The cumulative wastes from other related projects such as the Red Hill and Renegade mines must also be considered. Group 1 wastes from all such projects would eventually necessitate the establishment of a Class I or II-1 site in the vicinity if geothermal development proceeds to the full 600 MW. Siting such a facility would require study and coordination by all parties, including developers, BLM, NWC, RWQCB and other agencies.

2.12.2.5 Transportation and Traffic Systems

Access to the leasing area would be along Highway 395 and Coso Road (see Figure 2.12.2-1). Growth or traffic volumes along Highway 395 could bring the total to three or four times present volumes by the year 2030 still well below capacity (Caltrans, 1979). Further widening is planned. Project-related traffic at maximum employment could amount to slightly over 1,000 vehicles/day (vpd), or 500 round trips, including 200 or more heavy vehicles, an increase of only 23 percent over present levels. No congestion along Highway 395 is anticipated except at Coso Junction rest stop, where slowing and turning of heavy trucks could pose a traffic hazard. In the two-lane segment below Pearsonville, slow-moving trucks may also constitute a hazard. Increase of traffic to several hundred vpd over any of the roads within the CGSA is not possible without considerable improvement and widening. (Parking and storage areas would be provided at work sites.) Traffic impacts of the lower-level development scenario would be approximately half the above estimate.

The location of employees residences could have a bearing on traffic impacts. Assuming in the most extreme case a concentration of 375-500 dwelling units in Rose Valley, employees would probably carpool to the extent possible, reducing impacts on the CGSA roads.



1978 ANNUAL AVERAGE DAILY TRAFFIC AND PROJECT-RELATED TRAFFIC ON MAJOR ROADS WITHIN STUDY AREA

Figure 2.12.2-1

Vehicles using Coso Road beyond Sugarloaf Mountain would pass a prayer site visited by Native American groups; this site lies on both sides of the road. Approximately two miles farther east on this same road is Coso Hot Springs. Both springs and prayer grounds are part of a National Register site, and are especially important to Native Americans. Development-related traffic, dust, and noise in this area during their visits to these sites would constitute an intrusion and would result in loss of privacy. Mitigation proposed for the NWC program involves developing alternative access to avoid this area (NWC, 1979: 221). Vehicle emission and dust are discussed in Section 2.2.2.

Increased traffic throughout the local road ystem could be expected as a result of employees' and families' non-work-related trips, and possible sightweeing trips by the general public if geothermal development takes place in Zones 3 and 4. If use of rail transport is considered for construction equipment, Southern Pacific Railroad may continue its freight service between Pearsonville and Lone Pine (Hebb, 1979). Use of the existing siding at Sykes (see Figure 2.12.2-1) would require that the extension of Coso Road to that siding be improved. It would also necessitate crossing of Highway 395 by numerous heavy and probably slow-moving vehicles.

2.12.2.6 Employment

The proposed program would have a direct and indirect impact on employment levels in Inyo and Kern Counties with possibly a slight indirect impact on San Bernardino County. Indirect employment would be generated from two distinct project-related activities: (1) construction work force payroll spent locally, and (2) construction materials purchased locally. For every 100 direct jobs created locally by implementation of the program, another 65-82 indirect jobs will be generated by local payroll spending. This range seems reasonable in a desert area, not close to a major urban center, and without a diversified industrial base. It is assumed that indirect jobs would be filled by persons from the local labor pool, including some wives of 900 geothermal employees.

Most construction materials -- heavy drilling equipment, pipelines, pumps, fabricated steel for transmission towers, transmission line cable, turbines etc. will originate from outside the local area, much of this probably from out of state. Concrete, gravel, grading equipment, lumber and other basic building materials are available within the socioeconomic trade area; certain quantities may be purchased locally. It is assumed that 5 percent of all such materials will be purchased in Ridgerest and another 5 percent will be purchased in Inyo County.

Although some local labor may be available, it is assumed that the entire work force will be imported and will be represented by unions outside the area, such as Building and Trade Union Local No. 465 in Bakersfield. The entire local memberships in International Longshoremen and Warehousemen's Union Local No. 30 in Desert Lake (approximately 500 members) and Local No. 35 in Argus (approximately 450 members) are currently employed. Local No. 30 serves the Boron area borax extraction facilities and Local No. 35 serves the Kerr-McGee facility in Trona. Although members from these unions may be hired for program-related employment, it can be assumed that their positions would have to be replaced by other imported labor, since the facilities that both unions serve are now expanding operations.

During the start-up period temporary employees, even those living in Inyo County, are assumed to do virtually all of their local payroll spending (70% of total spending) in Ridgecrest; the 30% balance would be spent outside the study region. This local spending would generate 31 indirect jobs in Ridgecrest. Local construction materials spending would generate an additional eight jobs each, in Inyo and Kern Counties. Total indirect employment generated by the program would be 47, and total including direct employment would be 114. Closeout period impacts would be similar and slightly less, see Table 2.12.2-3.

In the maximum development scenario, if all employees live in the IWV area, again virtually all local payroll spending would be in Ridgecrest, generating 204 indirect jobs there; construction spending would add another 52 jobs in Inyo and Kern Counties. Total of indirect and average direct jobs would be 683. If all employees lived in Rose Valley, convenience shopping would probably develop there, and employee families would do additional shopping in Olancha and Lone Pine. This spending pattern wuld create more indirect jobs in Inyo County (108) than in Ridgecrest (82). In the lower level development scenario, total direct and indirect employment would be 313, with the preponderance of indirect jobs again in Ridgecrest.

2.12.2.7 Income

Estimated average annual payroll for program start-up and for each development scenario is also shown in Table 2.12.2-3. Average annual payroll for the start-up phase is estimated at approximately $27,500 per employee over four years. For the maximum development scenario, it is anticipated that payroll costs would be higher for a number of reasons: proof of substantial resources would tend to act as an incentive for the geothermal field operator to maximize the level of construction activity by encouraging overtime and double shifts in order to reduce work force turnover. Also, Zones 3 and 4 are assumed to require 50 percent more wells per MW than Zones 1 and 2. Efficiencies of operation would be enhanced by discouraging worker turnover through generous overtime pay schemes, and encouraging longer hours per worker.

Table 2.12.2-3 EMPLOYMENT IMPACTS OF PROJECT CONSTRUCTION (In thousands of dollars)

	Development Scenarios			
Assumed MW:	0	250	550	
	Start Up	Lower-Level Impact	Greatest Impact	
(1) Payroll Spending:				
Direct Employment (a)	67	190	375	
Total Direct Labor Cost (b)	$14,727	$455.131	$1,094,846	
Payroll @ 50% of Total Labor (c)	7,364	277,566	547,423	
Average Annual Payroll:				
Startup (4 years)(d)	1,841			
Development (45 years)(e)		5,057	12,165	
Average Payroll Spending @ 75% (f)	1,381	3,793	9,124	
			All Ridgecrest	Inyo/ Ridgecrest
Projected Spending Patterns:				
Ridgecrest:				
Percent of Total Spending (g)	70%	70%	70%	70%
Number of Workers	67	190	375	150
Payroll Spending	$ 967	$ 2,655	$6,387	$2,555
Inyo County:				
Percent of Total Spending (g)				42%
Number of Workers				225
Payroll Spending				$3,832
Indirect Employment Generated:				
Ridgecrest (h)	31	85	204	82
Inyo County (i)				108
SUBTOTAL	31	85	204	190
Average Annual Payroll Per Person (Direct Employment Only)	$27.48	$26.62	$32.44	$32.44

Table 2.12.2-3 EMPLOYMENT IMPACTS OF PROJECT CONSTRUCTION (continued)

	Development Scenarios				
Assumed MW:	0	250		550	
	Start Up	Lower-Level Impact		Greatest Impact	
(2) Construction Material Spending:					
Total Spending (j)	$14,149	$407,373		$989.779	
Annual Spending (k)	3,537	8,147		21,995	
Spending in Ridgecrest @ 5%(1)	177	407		1,100	
Spending in Inyo County @ 5% (2)	177	407		1,100	
Indirect Employment Generated:					
Ridgecrest (m)	8	19		52	
Inyo County (m)	8	19		52	
TOTAL	16	38		104	
			All Ridgecrest		Inyo/ Ridgecrest
(3) Total Indirect Employment Generated:					
Ridgecrest	39	104	256		134
Inyo County	8	19	52		160
TOTAL	47	123	308		294
(Effective Local Mulitplier)(n)	1.70	1.65	1.82		1.78

(a) Average employment over startup period (4 years) and development (45 years); estimates from Chapter 1 (Project Description).

(b) Calculated from Chapter 1 (Project Description).

(c) Assumes 50% of direct labor cost allocated to burden (such as fringe benefits); balance represents actual payroll before taxes.

(d) Average over five-year period.

Table 2.12.2-3 EMPLOYMENT IMPACTS OF PROJECT CONSTRUCTION (continued)

(e) Average over 45-year period; closedown phase of 2 years not included.

(f) Assumes 25% of actual payroll allocated to taxes, savings, investment, and non-local purchases; balance represents local payroll spending.

(g) Percents correspond to proportions of total construction workforce residing in each area, from development scenarios and startup estimate; it is assumed that 30% of Ridgecrest resident payroll spending will occur outside Ridgecrest and Inyo County and that 30% of Inyo County resident payroll spending will occur outside Inyo County and Ridgecrest; this is based on recent conversations with Coldwell Banker (June, 1979).

(h) Assumes that every $31,350 of local payroll spending (all retail items) will generate one indirect job; from U.S. Department of Commerce 1972 Census of Retail Trade: California, adjusted to January, 1979 dollars from U.S. Department of Commerce, Bureau of Labor Statistics, Consumer Price Indices.

(i) Uses same assumptions and data sources as in (h) above, except that ever $35,550 of local payroll spending will generate one indirect job.

(j) Calculated from Chapter 1 (Project Description).

(k) Average over five-year period during startup, 45-year period during subsequent development.

(l) Assumes that Ridgecrest and Inyo County will each contribute 5% of the total value of construction materials, both during startup and subsequent development.

(m) Assumes that every $21,250 of construction materials purchased locally will generate one indirect job; from U.S. Department of Commerce 1972 Census of Wholesale Trade: California, adjusted to January, 1979 dollars from U.S. Department of Commerce, Bureau of Labor Statistics, Consumer Price Indices; local materials spending assumed to largely concentrated in three two-digit Standard Industrial Classification (SIC) Codes: 24 (lumber), 32 (stone, clay, glass - includes gravel), and 35 (machinery).

(n) All direct and secondary employment expressed as a percent of direct employment only.

2.12.2.8 Major Industry

Within the study area, the proposed program would substantially increase the volume of construction activity, construction materials purchased locally, extractive industry, energy production, and recreation/tourism. The direct impacts on major industry, adjusted to January 1979 dollars, for each development scenario are presented in Table 2.12.2-4. These impacts would be more pronounced in Inyo County than in Kern County, with possible slight impact in San Bernardino County.

Materials and payroll spending resulting from the program would also generate indirect impacts on major industry, particularly housing construction in Kern and/or Inyo Counties.

2.12.2.9 Public Revenues

Sales and Use Taxes. Approximately 35 percent of total average annual payroll spending would be taxable, based on historical spending patterns for similar projects in California. The estimated sales and use tax revenues resulting from the proposed program are presented in Table 2.12.2-5.

The maximum impact scenario, assuming that private development is permitted in Rose Valley would result in annual revenues from subventions of approximately $19,900 to Ridgecrest, $5,000 to Kern County, and $85,500 to Inyo County. It should be noted that commercial development in Rose Valley could result in far more retail spending in Inyo County.

Kern County sales and use tax revenues totaled $10.7 million in FY 1977-78. Revenues from the proposed program, in its greatest impact scenario, would represent 0.5 percent of that amount. The City of Ridgecrest received sales and use tax revenues totaling $0.7 million in FY 77-78. Revenues generated by the greatest-impact scenario would represent 2.8 percent. Impact on Inyo County revenues would be substantially greater. In FY 1977-78 that county received sales and use tax revenues totaling $0.5 million. In the greatest-impact scenario, assuming concentration of employees in Rose Valley, the revenues generated by the proposed program would amount to 17.1 percent of the 1977-78 figure.

Property Taxes. The program would have a direct impact on the tax base of the study area (including assessed property valuation from program development improvements and the resource value of geothermal production) and on the sales tax base from local construction materials and payroll spending. The increase in assessed property valuation will be the result of power plant construction, including an electric transmission line, a water pipeline from Rose Valley, and the leasing and development of the geothermal resource. All direct increases in assessed property valuation resulting from the program would be received by Inyo County (see Table 2.12.2-6).

Table 2.12.2-4 ESTIMATED CONSTRUCTION COSTS (In Thousands of Dollars)

Construction Activity	Production Development Scenarios: Start Up	Lower-Level Impact	Greatest Impact
(1) Well Construction Costs			
Number of Wells	25	600	1,500
Total Material Cost (49%)	$14,149.1	$339,578.4	$848,946.0
Total Labor Cost (51%)	14,726.6	353,438.7	883,596.8
Total Well Cost (@1,003,500/well in 1977 dollars)	28,878.7	693,017.1	1,732,542.8
(2) Water Pipe Construction Costs			
Pump and Equipment			
Materials Cost (40%)		663.0	663.0
Labor Cost (60%)		994.4	994.4
Total Pump and Equipment Cost		1,657.4	1,657.4
(3) Main Pipeline ($50 per foot in 1977 dollars)			
Materials Cost (40%)		972.4	972.4
Labor Cost (60%)		1,458.5	1,458.5
Total Main Pipeline (@ 8 miles)		2,430.9	2,430.9
(4) Power Plant Construction Costs (@ $25 million per 50 MW including access and maintenance roads in 1977 dollars)			
Number of 50 MW Plants		5	11
Materials Costs (40%)		57,550.0	126,610.0
Labor Costs (60%)		86,325.0	189,915.0
Total Power Plant		143,875.0	316,525.0
(5) Transmission Line Costs			
Main line @ 8 miles			
Materials Cost (40%)		5,294.6	5,294.6
Labor Cost (60%)		7,941.9	7.941.9
Total Main Line Cost		13,236.5	13,236.5

(continued)

Table 2.12.2-4 ESTIMATED CONSTRUCTION COSTS (continued)

Construction Activity	Production Development Scenarios: Start Up	Lower-Level Impact	Greatest Impact
(6) Connector Lines (1 mile/50 MW plant)			
Materials Cost (40%)		$3,314.9	$7,292.7
Labor Cost (60%)		4,972.2	10,939.2
Total Connector Line Costs		8,287.1	18,231.9
(7) TOTAL CONSTRUCTION COSTS			
Materials Cost	$14,149.1	407,373.3	989,778.7
Labor Cost	14,727.6	455,130.7	1,094,845.8
TOTAL COST	$28,875.7	$862,504.0	$2,084,624.5

2.12.2-5 ESTIMATED SALES TAX REVENUES (In thousands of dollars)

	Production Development Scenarios			
Assumed MW :	0	250	550	
	Start Up	Lower-Level Impact	Greatest	
(1) Annual Total Materials Spending				
Start-up (@ 4 years)	$3,537.0	$8,147.0		$21,995.0
Development (@ 45 years)				
(2) Estimated Annual Materials Spending by Area (from Employment Impact Table)				
(a) Ridgecrest (@ 5% of #1)	176.9	404.4		1,099.8
(b) Inyo County (@ 5% of #1)	176.9	407.4		1,099.8
(c) Rest of California (@ 70% of #1)	2,475.9	5,702.9		15,396.5
(d) Outside California (@ 20% of #1)	707.3	1,629.3		4,398.9
(3) Estimated Annual Sales & Use Tax Revenue From Materials Spending by Area				
(a) Kern County (@ .25% of line #2a)	0.4	1.0		2.8
(b) Ridgecrest (@ 1% of line #2a assuming all spending in Ridgecrest)	1.8	4.1		11.0
(c) Inyo County (@ 1.25% of line #2b, and 1.25% of line #2d assuming all use tax in Inyo	11.0	25.5		68.7
(4) Average Annual Payroll Spending By Area (From Employment Impact Table)			All Ridgecrest	Inyo-Ridgecrest
(a) Ridgecrest	967.0	2,655.0	6,387.0	2,555.0
(b) Inyo County				3,832.0

Table 2.12.2-5 ESTIMATED SALES TAX REVENUES (continued)

	Production Development Scenarios			
Assumed MW:	0	250	550	
	Start Up	Lower-Level Impact	Greatest Impact	
(5) Estimated Annual Average of Taxable Payroll Spending by Area (assuming 35% of line #4 is taxable)			All Ridgecrest	Inyo/ Ridgecrest
(a) Ridgecrest	$ 338.5	$ 929.3	$2,235.5	$ 894.3
(b) Inyo County				1,341.5
(6) Estimated Annual Sales Tax Revenue from Taxable Payroll Spending by Area				
(a) Kern County (@ .25% of line #5a)	0.9	2.3	5.6	2.2
(b) Ridgecrest (@ 1% of line # 5a)	3.4	9.3	22.4	8.9
(c) Inyo County (@ 1.25% of line #5b)				16.8
(7) Estimated Total Annual Sales Tax Revenue from Taxable Materials and Payroll Spending by Area				
(a) Kern County (Lines #3a & 6a)	1.3	3.3	8.4	5.0
(b) Ridgecrest (Lines #3b & 6B)	5.2	13.4	33.4	19.9
(c) Inyo County (Lines #3c & 6c)	11.0	25.5	68.7	85.5
TOTAL LOCAL REVENUE	$17.5	$42.2	$110.5	$110.4

Table 2.12.2-6 ESTIMATED PROGRAM-RELATED MARKET VALUATIONS IN 2010
(Thousands of 1979 dollars)

	DEVELOPMENT SCENARIO	
	Lower-level development	Greatest Impact
Power Plant Construction[1] (Including Transmission Line)	$ 69,827	$ 172,457
Water Line Construction[2]	4,088	4,088
Fair Market Value of Geothermal Resource ($320,000/MW	80,000	176,000
Total Market Value	153,915	352,545
Assessed Value (25% of Market Value)	38,478	88,136
Percent of 1979 Inyo County Assessed Valuation ($121,509)	31.7%	72.5%
Percent of 2010 Inyo County Assessed Valuation ($224,222)	17.2%	39.3%

1. Construction costs from Table 2.12.2-4. Values are depreciated using a 30-year facility life.

2. Table 2.12.2-4.

3. The current market value for Sonoma County geothermal steam is $20 per pound of pressure (Mr. Ken Cory, Senior Appraisor Sonoma County Assessor's Office). Based on the project description estimate of 800,000 pounds of steam for a 50 MW power plant, the per MW steam value is $320,000.

Valuation of geothermal resource in Sonoma County, the California County with the most geothermal experience, is determined on the basis of the both possessory interest (market value of leasehold) and the value of the resource. This method assigns possessory interest to successful exploratory wells ($20,000-$30,000 per well in 1977). As portions of a field go into production, the possessory interest of the producing portion is removed from the assessment roll and replaced by a geothermal resource value ($20 per pound of produced steam in 1979).

Public utilities are valued by the State Board of Equalization, based on the market value of the stock, the rate base, and other factors. The physical facilities are value at their location based on the historical cost of the facility less accumulated depreciation. The statewide assessed value for each utility is allocated back to each taxing jurisdiction based on the replacement value less depreciation for each facility in the taxing jurisdiction. Attempts to assign the Coso facilities to a public utility (DWP or SCE) and to estimate replacement costs, rate bases, corporate stock values and debt are beyond the scope of this report. Therefore, the assessed valuations presented in Table 2.12.2-6 do not reflect Board of Equalization assessment practices, but only historical cost less accumulated depreciation. The power plants are depreciated over a 30-year period from the plant's first year of operation. The first year of operation of the initial and final power plants for each development scenario are: lower-level (1986-2000), and greatest-impact (1985-2010).

The proposed program would have a significant impact on Inyo County's projected assessed valuation for the year 2010. Over the period 1968-1978, real assessed valuations increased by an average of 1.76 percent per year. The statewide 2 percent limit on annual increases in assessed valuation will have a small effect on this trend (should it continue), since many properties will change hands and be reassessed at real market values, as will new construction. The lower-level development scenario would increase projected Inyo County 2010 assessed valuations by 17 percent. The greatest impact scenarios would increase 2010 assessed valuations by 39 percent.

<u>Revenues from Geothermal Leasing</u>. Under the provisions of FLMPA (see Glossary), Section 317 (a), 50 percent of all revenues received from the proposed program would be returned to the State of California "to be used by such State and its subdivisions, as the legislature of the State may direct, giving priority to those subdivisions of the State socially or economically impacted by the development of minerals leased under this Act." Revenues that fall under this provision are the bonus bid, rental, and royalty revenues.

The bonus bid represents the purchase price of the right to develop the geothermal resource and to assume the lease. This is a one-time cost to the developer prior to award of lease. Before bidding on the lease, however, potential bidders are informed of the rental and royalty rates. Under current BLM practices, the rental rate is set at $2 per acre and the royalty rate is 10 percent of the annual production value of the geothermal resource as determined by the USGS. In general, rental on federally administered land is paid to the BLM until the resource is brought into production; thereafter payment is continued in the form of royalties, paid to USGS. (Rates may be readjusted later according to a general formula given in 43 CFR 3205.) There are no producing geothermal leases on federally administered lands in California as yet.

The Roosevelt Hot Springs KGRA in Utah, probably the geothermal area most comparable to the Coso area, was first leased in 1974; accepted bonus bids ranged from $5 to $128 per acre (or $7 to $188 in 1979 dollars). Development of the CGSA could yield significant annual royalty revenues. In the year 2010, under the greatest-impact scenario, approximately $2 million in royalties would be divided between Federal and state governments (see Table 2.12.2-7).

Table 2.12.2-7
ESTIMATED PROGRAM-RELATED ROYALTY PAYMENT IN 2010
(In Thousands of 1979 Dollars)

	Development Scenario	
	Lower-Level Development	Full Development
Assumed MW (BLM Leases)1	250	550
Annualized Value of Resource (at $36,800/MW)[1]	9,200	20,240
Royalty at 10%	920	2,024
California Share	460	1,012

1. Fair market value annualized over 30 years at 11%.

At present there is no legislation in the State of California to provide for the distribution of such geothermal revenues between the state and counties or other local jurisdictions.

Other Public Revenues. The proposed project would also result in a direct increase in a number of one-time revenues in Inyo County, for example, revenues from planning, building, and inspection fees associated with program development.

2.12.2.10 Public Expenditures

Direct increase in the marginal work loads of public employees (e.g., general government, fire, and police) as a direct result of the geothermal development, would be relatively insignificant and would not require any increase in public expenditures. However, the program could generate an indirect (population growth-related) need for additional public expenditures.

In the maximum impact case, all employees live in IWV, Kern county would incur the costs of adding one or two employees and associated equipment to the existing fire/ police protection systems a possible total of $60,000 per year plus a one-time purchase of equipment. At the same time, however, the County would experience the economic stimulus of payroll spending as discussed above; essentially no payroll spending would be expected to occur in Inyo County under this scenario. On the other hand, regardless of the residential pattern established, the public revenues from geothermal development would accrue to Inyo County.

Assuming development is permitted in Rose Valley, the greatest-impact scenario would require approximately three to six additional sheriff's department personnel, at a total cost of approximately $100,000-$200,000 a year;

one or two support vehicles at a cost of approximately $10,000 each, plus maintenance and gas; and possible construction of a new substation in Olancha. The Inyo County Sheriff's station in Olancha recently completed a jail addition at a cost of approximately $750,000; construction of a new substation would probably bear a capital cost in excess of this amount. This scenario would also require expansion of volunteer fire protection in Olancha or formation of a new district and acquisition of equipment. A new fire station would probably bear a capital cost similar to that of the sheriff's substation. A new pumping truck, a hook-and-ladder truck and one automobile would require approximately $275,000. Though no payroll would be involved in a volunteer district, equipment maintenance and fuel costs would be incurred.

It is assumed that the Lone Pine Unified School District could accommodate any additional requirements without additional costs. It is unlikely that the Sierra Sands Unified School District would need additional facilities as a result of the proposed development.

It is assumed that the cost of increasing other utility capacity (gas, electricity, etc.) would be borne by user fees and hookup charges. No other public service costs are anticipated as a result of the proposed program.

In the lower-level development case, the indirect impacts would be approximately half of those described above. The effect of temporary NWC employment must also be considered; this would involve increase in the work loads of public employees but probably no increase in public expenditures during the five years of construction.

2.12.2.11 Public Attitudes

A discussion of the public opinions, expectations, and expressions of perceived well-being can be found in Section 2.12.1.12.

2.12.2.12 Native American Concerns

Native American concerns regarding the proposed action are described in Section 2.12.1.13.

Noise impacts are discussed in Section 2.3.2, where noise contour maps for the Prayer Site and Coso Hot Springs are shown (assuming a power plant within one mile of each site). Development or operational noises that are at background levels would not interfere with ordinary activities. However, the concern of the Native American groups is that, for persons engaged in prayer and meditation, any non-natural auditory intrusion may be distracting (for example, even a distant, constant, low-level sound of machinery, they feel, might be obtrusive whereas a nearby birdcall might not). This is a statement of concern, as perceived by researchers, and not necessarily a potential impact. Intermittent traffic noises (see Section 2.12.2.5) would also be a source of disturbance during visits to these sites.

The possibility of altering the flow or character of the springs is discussed in Section 2.5.2, and careful monitoring and reinjection are suggested as mitigation (see Chapter 3); but at this preliminary stage of analysis no certain reassurance can be given to the Native Americans. The healing qualities attributed to the Springs and the traditional interrelationship between religion and healing, give Coso Hot Springs great significance for them. In general, as suggested in the preceding paragraph, they appear to feel that any man-made alteration in the existing conditions would be a negative impact.

Local groups have been assured of the general (and official Federal) concern for protection of archaeological sites, but they are also aware of the possibility of increased vandalism or accidental destruction. See Sections 2.10 and 3.9 for further discussion of cultural resources impacts and mitigation.

Recent apprehension over access to the Prayer Site and Hot Springs has partially abated due to the access agreement signed with NWC guaranteeing eight scheduled visits per year. The unscheduled visits (on request due to special need on the part of some person or group) will undoubtedly have to be worked out by accommodations and compromises on both sides, due to the special nature of the requests and the special mission of the NWC.

Other impacts which may affect visiting Native American groups, and which are also of general public interest, include visual (discussed in Section 2.9) and air quality (see Section 2.2).

2.12.2.13 Summary of Impact by Geographical Area

Kern County. The Ridgecrest/Inyokern/Brown Road area could probably absorb the maximum impact of full field development, including the possible eventual in-migration of 375-500 families without too severe a strain. There would be sufficient private land, and probably sufficient housing by the year 2000, when 500 workers might be employed at the leasing sites, assuming future housing starts at the currently projected rates. In the interim, however, it is assumed Ridgecrest and Kern County (for rural Indian Wells Valley) would have solved present problems with regard to infrastructure capacity which have been aggravated by rapid absorption of population from China Lake. Even in the maximum-impact case examined in the foregoing discussion, the project-related population of 1,500 people would constitute only 4 percent of the area's expected total in the year 2010. The additional burden on local support systems would be offset to a great extent by the economic stimulus provided by the proposed program. This would include the creation of indirect employment for some 200 local residents as a result of payroll spending by project employees, and the generation of additional annual sales tax revenues of approximately $42,000 for Ridgecrest and Kern County.

The lower-level development scenario envisions approximately half the above number of employees, only 570 new permanent residents, and concentration of employee housing at first in Ridgecrest/Indian Wells Valley but with a "ripple" of spillovers into southern Inyo County. Impacts on Ridgecrest and IWV—both the burdens on infrastructure and the economic benefits--would be accordingly diluted.

Inyo County. The impact of the proposed development upon Inyo County would be more pronounced and complex, due to the lack of infrastructure systems in this thinly populated area. During start-up, estimated at 3 or 4 years, approximately 67 persons would be employed. It is assumed they would seek temporary housing, probably in Ridgecrest/Inyokern; NWC temporary personnel would probably have filled any temporary accommodations in southern Inyo County. However, developer-furnished temporary housing is suggested for NWC geothermal development (NWC, 1979); if this is provided, some existing temporary facilities may be locally available for employees of BLM-sponsored development.

In the lower-level scenario, an average of 190 essentially full-time employees is assumed, with most of these living in Indian Wells Valley at first; over time, some would probably move to southern Inyo if County and other policies permit construction there. Even if policy discourages development, some would probably elect to move into available housing in Lone Pine or Olancha; some may choose mobile homes in existing parks if long-term tenancy is permitted, or in remote locations. The impact of this in-migration, even in small numbers over time, would be noticeable in such a sparsely populated area with a paucity of support systems. (Any substantial population increase in Cartago or Lone Pine would require upgrading of existing sewer systems.) The program's economic benefits to Inyo County would compensate in part for the costs involved in incremental improvements to infrastructure capacity. Some 85 indirect jobs would be created by local payroll spending, and largely filled by local residents. Approximately $25,500 yearly in sales and use tax revenues would accrue to Inyo County; and increases in assessed values would amount to some 17 percent more than the projected 2010 total valuation for the county.

Analysis of the maximum-impact scenario is conjectural. The assumptions are 550-MW development on several leases simultaneously by several contractors, no unitization, no developer-supplied housing, and concentration of 375-500 employee families (in this case, in Rose Valley or Olancha). The economic benefits would accrue largely to Inyo County, although without considerable expansion of commercial development in southern Inyo, a sizeable proportion of payroll spending would still occur in Ridgecrest. Approximately 110 indirect jobs would still be created locally by payroll spending, as well as $85,500 in annual county revenues for sales tax subventions; assessed valuation would increase by 39 percent over projected 2010 county valuation.

However, the uncertainties regarding county, BLM and NWC policies and plans for the region make such a housing scenario--at Dunmovin, for example--highly speculative. Even if such a development were permitted, there would be many difficulties and expenses surrounding a development of this magnitude in a rural area, together with necessary support systems. These expenses, furthermore, would be incurred prior to the time when public revenues would be realized from the project.

If appropriate solutions can be found for the problems posed by housing and infrastructure, policymakers may decide that the benefits of a well-planned housing and commercial development in northern Rose Valley outweigh the disadvantages. On the one hand, the program's economic benefits--including diversifying and stabilizing the County's economy--would be enhanced by the encouragement of greater local payroll spending. On the other hand, even the best-designed housing and satellite development accommodating up to several hundred families would alter the character of this rural area. Many local residents may be unwilling to accept this change toward urbanization.

At whatever level of geothermal development, and regardless of the residential patterns established, the program would have potential impact upon Coso Hot Springs and the Prayer Site. Both are National Register sites, and both are of great importance to local Native American groups. Their concerns are discussed in Section 2.12.1.13; possible impacts are addressed under Air Quality, Noise, Land Use, Traffic, Hydrology, and Socioeconomics.

3.0 MITIGATION MEASURES

The material in this chapter presents measures, which if implemented, would mitigate the impacts of the proposed action as described in Chapter 3. The proposed action of the BLM is to lease parcels of land for the purpose of developing the known geothermal resource. Some of the mitigation measures proposed are amenable for inclusion in the leases as stipulations. After leasing, supervision of the development and enforcement of the lease conditions becomes the responsibility of the USGS. Federal Regulations (*) require that geothermal lessees and operators submit a plan of operation for production which includes:

> "A requirement for the collection of data concerning the existing air and water quality, noise, seismic, and land subsidence activities, and ecological systems of the leased lands covering a period of at least one year prior to the submission of a plan for production."

The GS normally requires five types of submissions or plans for approval in addition to the baseline studies. These are:

1. Notice of Intent for Exploration - For initial study purposes prior to intensive exploration.

2. Plan of Operation - Including geologic and geophysical surveys, shallow temperature gradient holes, and deep exploration drilling.

3. Plan of Development - Including development drilling, permanent roads, pipelines, and other facilities.

4. Plan of Utilization -Describes proposed use of the resource and siting plans for surface structures.

5. Plan of Production - Including operation of wells and facilities for production and use of the geothermal energy.

The lessees and operators must follow the directions of GS as given in the

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* Code of Federal Regulations, Part 30, Par. 270.34(k).

"Geothermal Resources Operational Orders" (GRO) issued by this agency. These orders cover various specific details of exploration and development. The enforcement of these GROs effectively mitigates many of the impacts described in Chapter 3. The GROs issued to date include:

1. Exploratory Operations
2. Drilling, Completion, and Spacing of Geothermal Wells
3. Plugging and Abandonement of Wells
4. General Environmental Protection Requirements
5. Plans of Operation, Permits, Reports, and Forms (Draft)
6. Pipelines and Surface Production Facilities
7. Production and Royalty Measurement, Equipment, and Testing Procedures

In addition the NWC will review all such plans to insure that any development does not interfere with the mission of Navy.

Thus, although the impacts and the mitigation measures described in this ES are quite general, there is provision to insure that site-specific impacts can be mitigated by the reviewing agencies after the proposed action has taken place.

the BLM should provide specific stipulations and not rely on other fed. agencies

3.1 AIR QUALITY MITIGATION MEASURES

Air quality impacts may result from exceedances of both hydrogen sulfide (H_2S) and suspended particulate standards. Mitigation measures for both species are presented here.

Exceedance of the state H_2S standard is not predicted under most meteorological and emissions conditions. However, such exceedances are projected under special conditions. Therefore:

1. A monitoring program will be implemented by the developer whenever flow testing is initiated at a site which is downwind of a producing power plant. Such monitoring, and cessation of activities if necessary, should avoid the problem of excessive H_2S levels. (why is this so specific?)
2. H_2S "state-of-the-Art" well-head & power plant abatement.

More extensive mitigation measures will be required for fugitive dust than have been presented for hydrogen sulfide. All State of California and Federal standards for total suspended particulate (TSP) are projected to be exceeded during the exploration and field development stages. Proposed mitigation measures for TSP are:

1. Water roads and exposed areas undergoing activity. (This is a proven dust control method.)

2. Require the operators to submit a dust abatement plan along with the Plan of Operations which may include water, gravel, etc.

3. Provide transport for employees traveling in groups of 6 or more by bus from U.S. 395 in order to reduce the number of vehicle trips.

3.2 NOISE MITIGATION MEASURES

The siting of wells and power plants is critical in considering noise mitigation measures. If it is determined that a proposed geothermal activity will occur a mile and a half or more from a sensitive receptor (see Section 2.3.2), then the resulting noise will be inaudible at the receptor and no mitigation will be necessary. If the source-receptor distance is less than one and a half miles, the following mitigation measures can be applied:

1. Reduce truck deliveries and geothermal operations at night whenever technically feasible in order to reduce the noise impact, which is greater at night. This mitigation measure should be applied to all sensitive receptors which are used for sleeping or for nighttime religious observances and which lie within one and a half miles of a power plant or within one mile of a plant access road. The list of such receptors should include Rose Valley Ranch, Coso Hot Springs and the Prayer Site (see also 2A, below).

2. The following mitigation measures should be applied to all leases which lie within one and a half miles of Coso Hot Springs or the Prayer Site, or which require access along any road which passes within one mile of Coso Hot Springs or the Prayer Site:

   A. During period of Native American use of the Prayer Site or Coso Hot Springs, eliminate truck deliveries which must use roads passing these sites, especially at night. Specific authorization to bypass this mitigation may be given by the Area Supervisor after consultation with BLM on a case-by-case basis.

   B. Avoid well testing within one and a half miles of the Prayer Site and Coso Hot Springs during periods of Native American religious observances. To implement this mitigation, Native Americans will notify USGS of their entrance schedule at least 10 days beforehand.

3. The Lessee will monitor sound levels, pursuant to GRO #4 section 11.G specifications, of any permanent operations which may be later proposed for areas within 1.5 miles of sensitive receptors. Using these data the lessee or power plant proponent shall perform a noise attenuation study which considers topographical barriers for noise sources proposed to be placed within a 1.5 mile radius of a sensitive receptor. Lessees will be required to demonstrate that such facilities will not impact the sensitive areas (L_{eq} less than 28 dBA with no wind).

3.3 GEOLOGY MITIGATION MEASURES

1. All structures will be designed to meet the applicable State of California and/or Inyo County codes and earthquake standards, and of the USGS Area Geothermal Supervisor.

3.3.1 Land Surface Deformation

1. Lessees will be required to meet the USGS monitoring requirements of GRO #4. for subsidence

spell out - don't leave it all to USGS!

3.4 HYDROLOGY MITIGATION MEASURES

1. Implementation of the Hydrology Monitoring Plan is necessary for all hydrology mitigation measures. Such monitoring shall be implemented by the lessee no later than one year before Plans of Operation are implemented. Monitoring will be subject to review by USGS.

3.4.1 Lowering of the Water Table in Rose Valley

The amount of acceptable water table lowering would be determined by the BLM, Inyo County, and Los Angeles Department of Water and Power policy and local economics. When this determination is made, further study will be required to determine which of the following possible mitigation measures will be necessary or feasible:

1. Lessees will submit a water management plan as part of the plan of production. This plan could include potential importation of water obtaining water from nearby sources, and the following two mitigation measures:

   A. Injection of spent geothermal fluid at depth, beneath fresh water, in Rose Valley.

   B. Artificial recharge or monitoring in Little Lake.

The nearby alluvial valleys do not contain nearly as much water or have as much recharge as Rose Valley. However, they may be able to supply some of the required cooling water and thereby reduce the amount extracted from Rose Valley. For example, recharge into Upper Coso Basin is estimated at 390 acre-feet/year. If most of this water could be captured it could supply enough cooling water for one 50 MW power plant. Ground water extraction from Upper Coso Basin would reduce underflow to Indian Wells Valley as extraction from Rose Valley would.

Injection of spent geothermal fluid beneath or at the bottom of the fresh water aquifer in Rose Valley would raise the water table. Although the geothermal fluid and the fresh ground water are miscible, the density difference between them would tend to keep the geothermal fluid beneath the fresh water. A comprehensive ground water basin survey and modeling would have to be conducted prior to implementation of such a plan. Even though this scheme would keep the water table up, the amount of usable ground water in storage would still be reduced.

Monitoring as specified in the monitoring plan, will aid in determining proper level for Little Lake. It may then be maintained, as it has been in the past, by feed from wells just north of the lake. Keeping this water level up should also maintain underflow to Indian Wells Valley.

3.4.2 Degradation of Natural Water

Mitigation for degradation of natural water can be divided into four catagories:

A. Design of surface facilities

B. Blowout prevention devices, and

Because most GRO's are vague BLM should be specific in their leasing stipulations so the prospective lessee is fully aware of environmental conditions.

C. Ground water and geothermal reservoir monitoring

D. Injection well design

GRO's No. 2, 4, and 6 specify mitigation measures for these categories. Within the constraints of current technology, the GRO's are formulated to mitigate all known potential impacts. Surface facilities, including all conveyances and sumps, must be designed to safely contain anticipated capacities, temperatures and chemical composition. GRO No. 6 specifies requirements for pipelines and surface production facilities. It states that they must be designed to withstand thermal stresses and two phase flow. They must be designed with safety control devices such as automatic shut-off valves. The facilities must be tested and monitored regularly.

NO

GRO No. 4 specifies that pits and sumps shall be lined with impervious materials to prevent escape of contained fluids into ground or surface water. All potentially harmful materials shall be removed before backfilling and disposal areas should be restored to natural appearances. Fencing during use to protect wildlife, livestock and public may be required if needed.

GRO No. 2 specifies use of blowout prevention equipment and procedures. This includes installation and testing of blowout preventers with high temperature and pressure capacity components. The system shall have manual and hydraulically actuated valves and dual control stations.

GRO No. 6 discusses injection facility regulations. It specifies that injection facilities must:

A. Be designed to withstand anticipated pressures.

B. Have an automatic pressure actuated shut-in device or pressure relief valve, and

C. Check valves to prevent backflow.

3.4.3 Alteration of Flow to Coso Hot Springs

The Hydrology Monitoring Plan (Appendix D), to be implemented by the lessees, will include monitoring of Coso Hot Springs. If monitoring shows that the flow to Coso Hot Springs is altered by geothermal production, the lessees will develop and implement a strategy to restore the flow by selective placement and regulation of injection and production wells. USGS, BLM and NWC will approve such strategy prior to implementation. Monitoring will be continued by the lessees to determine the effectiveness of the mitigation strategy.

3.4.4 Localized Cooling, Mineral Precipitation and/or Depletion

Localized cooling around injection wells could be mitigated by halting injection. However, with proper design and reservoir engineering, this should not be a problem. In fact, recirculation of cooler water in hot rocks can contribute to increased resource recovery. Mineral precipitation and resource depletion can be minimized by proper well management practices.

3.4.5 Flood Hazard

Flood hazards can be mitigated by proper siting of facilities and proper engineering to protect facilities from flood. Areas subject to periodic flash floods are delineated on Plate 2.6-1, General Soils Map and Soil Sensitivities.

Hazard due to inundation by failure of South Haiwee Dam can be avoided by not siting facilities in the inundation area outlined in Appendix D of the Hydrology Technical Report.

3.5 SOILS MITIGATION MEASURES

3.5.1 Mitigation Associated with Exploratory Operations

Vehicles and construction equipment used during exploratory operations and subsequent development shall be subject to the following mitigation measures:

1. The Plan of Operations for geophysical explorations shall include proposed routes of travel where departure from roads is required. Routes shall be chosen to create the least disturbance to soil and vegetation. Soil maps and tables should be consulted in planning all routes.

2. Vehicle travel off of roads shall be restricted when the soil surface is wet or moist in order to reduce soil compaction and the potential for generating ruts and wheel holes, as directed by the Area Supervisor.

3. Vehicle speed of all vehicles on roads and trails shall be minimized to reduce dust generation.

3.5.2 Mitigation Measures During Field Development

what are these

1. Sections 9110 and 9111 of the Bureau of Land Management manual shall be used as guidelines in all construction activities with case-by-case modifications of such recommendations as are presented below. Standard specifications for Construction of Roads and Bridges on Federal Highway Projects (USDOT, FP-74) can also be used as guidelines. All roads will also meet the State, Local and NWC specifications.

Drill Pad, Mud Sump, and Reserve Pit Construction

1. Topsoil resources having value for revegetation efforts shall be stripped, stockpiled, and stabilized in suitable sites prior to and during all earthwork activities. Topsoil suitability of soil types is presented in the Soils Technical Report, Table 7-5, Interpretive Ratings for Soil Uses.

will this measure be appliable to Coso? no direction on this proposal.

3.6 MITIGATION OF IMPACTS ON WILDLIFE

1. Where present, topsoils will be stockpiled and replaced evenly over disturbed areas which are no longer necessary for geothermal operations. Seeds of native plants which have high food value for mammals will be scattered for revegetation. These shall include, if possible, Amsinckia tessellata, Coreopsis Sp. and Lycium Cooperi. The BLM wll help determine appropriate species at that time. Such restoration will occur as closely as possible to early fall (prior to the rainy season). Restoration in the fall months will lessen the degree of wind erosion to the replaced topsoil and seeds.

what about birds? what about USFWS

Prior to surface disturbance in an area inhabited by Mohave ground squirrel, a population study to determine density of the squirrel for the particular habitat type to be disturbed ~~will~~ will be performed as part of the USGS EA on the submitted Plan of Operations. From this information, the number of squirrels lost per power generating unit will be calculated and necessary mitigation levels (revegetation and habitat improvement) will be established by the surface managing agency.

by who?

2. Aquatic Habitats. A hydrologic data gathering and monitoring plan will be implemented to record the potential lowering of Little Lake water levels and to determine actual ground water recharge in Rose Valley. Lessee will be responsible for implementation of the monitoring plan.

Measures outlined in Section 3.4.1 (Hydrology) for maintaining the water table in Rose Valley will be implemented if feasible (i.e., it may not be possible to capture sufficient recharge from Upper Coso Basin and other alluvial valleys to supply a significant amount of cooling water.)

3. Raptor and Mammal Habitat. Where possible, exploration and construction activities will be avoided between March 1 and June 30 (the period when birds are nesting and small-mammals activity is greatest) in those areas which have been identified as sensitive; see Section 2.7.2 and Figure 2.7.2-1. A noise/disturbance buffer zone of one-half mile or more (depending on the noise levels of the proposed activity —see Section 2.3.2 and following paragraph) shall be maintained around such areas, if possible, until demonstrated to the satisfaction of the Supervisor that the operations will not disturb the nesting/breeding activities. These areas include:

   A. Raptor nesting habitats in cliffs east of Little Lake, in the lava cliffs southeast of Coso Hot Springs, in the rocky ridges near Haiwee Spring and northwest of Cactus Peak (Sections 15, 16 and 21 and T21S R38E), and other cliffs/rocky ridges between Volcano Peak and Sugarloaf Mountain; and any other raptor habitats subsequently identified.

   B. Nesting bird habitats in areas of Joshua Tree concentration (see Section 2.7.2).

   C. Probable carnivore denning sites, i.e., the areas mentioned in (a) above, additional possible sites northeast of Cactus Peak and south of Sugarloaf Mountain. The ringtail, protected under California law, is likely to den in these areas.

In addition to the above general stipulations, USGS EAs on Plans of Operations will include data collected by a qualified biologist on any current nesting or denning sites or other sensitive areas to be avoided and shall specify size of noise/disturbance buffer zones to be maintained around these sites or areas.

4. Feral Burros. The lessee should notify the Area Supervisor of any damage to facilities caused by burros. BLM and the NWC will then determine appropriate modifications to their individual Burro Management Plan to reduce incompatibilities.

5. Transmission Line Construction. Construction of transmission lines will follow guidelines established by the Raptor Research Foundation in 1975, so that electrocution of large birds does not occur.

What about watering of seed beds?

3.7 MITIGATION OF IMPACTS ON FLORA

1. Where present, topsoils will be stockpiled and replaced evenly over disturbed areas which are no longer necessary for geothermal operations. Seeds of native plants which have high food value for mammals will be scattered for revegetation. These shall include, if possible, Amsinckia tessellata, Coreopsis sp. and Lycium cooperi. The BLM will help determine appropriate species at that time. Such restoration will occur as closely as possible to early fall (prior to the rainy season). Restoration in the fall months will lessen the degree of wind erosion to the replaced topsoil and seeds.

2. Where vegetative control is necessary, mechanical rather than chemical methods will be employed.

3. Surface disturbance will not occur on the localized habitats (see Figure 2.8.2-1) for the CNPS-listed Pholisma arenarium and Spartina gracilis.X All vegetative surveys shall include a specific search for Pholisma arenarium, and Canbya candida. If possible, surface-disturbing activities should not occur on the habitats of Canbya candida.

What about water drawdown at Little Lake?

3.8 VISUAL RESOURCES MITIGATION MEASURES

The mitigation of impacts of the proposed project is divided into two categories:

1. Those mitigation measures which will be applied to sensitive (Class II) lands within the CGSA, and

2. Those mitigation measures which will be applied to less sensitive areas.

3.8.1 Mitigation Measures for Class II Areas

1. No permanent visible structures will be permitted on Class II lands except those which meet requirements of blending in with the background in terms of form, line, color and textures. Such structures will be limited to pipelines, transmission lines, roads, and similiar lineal elements.

2. The design and routing of each of these facilities will be planned and approved by the USGS and BLM prior to implementation to insure that they minimize visual impacts and maintain the overall esthetic pattern of the area.

3.8.2 Mitigation Measures for Other Areas

1. All required land scarification will be revegetated as soon as practicable. Power generation stations will be located in areas such that they minimize impacts from sensitive viewing points and such that they are unobtrusive to the eye.

3.9 CULTURAL RESOURCES

3.9.1 Introduction

In compliance with 36 CFR 800.4, the State Historic Preservation Officer and the National Advisory Council on Historic Preservation will be consulted to obtain concurrence on all proposed mitigation measures for cultural resources within the CGSA that may be impacted as a result of geothermal development. In addition, all proposed mitigation of impacts to sites determined to be eligible for inclusion in the National Register will be approved and implemented by concurrence of the BLM (where applicable) and NWC. The California Native American Heritage Commission and the local Native American community will be afforded the opportunity to review proposed mitigation measures.

As discussed in Chapter 2, the cultural resources inventory completed for this ES provided important data concerning the density, distribution, and overall significance of cultural resources within the CGSA. Several types of cultural resource sites were encountered and recorded during the course of the inventory, 55 percent of which were classified as lithic scatters.

Collectively, the cultural resources within the CGSA constitute a significant array of data that appear to qualify for inclusion on the National Register as a thematic group (see Section 2.10). However, the "masking effect" of the air-fall (pyroclastic) obsidian from Sugarloaf Mountain precludes a clear definition of the research potential of the lithic scatters. No single set of measures could presently be implemented to adequately mitigate impacts to every site type recorded. Therefore, in addition to mandated measures discussed in Section 2.10.2, this plan provides for three kinds of direct mitigation to solve the problem: cultural resource site avoidance, development and implementation of a strategy to penetrate the obsidian "masking effect", and data recovery. Only by implementing such a plan can appropriate mitigative measures be developed to include areas and sites yet to be inventoried during the course of geothermal development.

Thus, there are three assumptions guiding the proposed mitigation plan:

1. The cultural resources within the CGSA are collectively considered to meet the eligibility criteria for inclusion in the National Register of Historic Places as a thematic group.
2. The important obsidian source at Sugarloaf Mountain which was greatly utilized by aboriginal people, has created a "masking effect" (discussed in Chapter 2), which partially obscures the significance of one cultural resources site type within the CGSA, the lithic scatters.
3. This mitigation plan, in addition to the mandated measures discussed in Section 2.10.2, will provide the guidelines to facilitate compliance with the requirements of Federal historic preservation legislation through appropriate levels of cultural resources site avoidance and data recovery.

3.9.2 Mitigative Measures

The following mitigation measures will be implemented to encompass all lands within the CGSA which are proposed for geothermal leasing and development.

The responsible BLM archaeologist will coordinate, review and approve all procedures and reports as part of the implementation of Cooperative Procedure WO 105 (see Appendix C) which is a supplement to the USGS BLM, and U.S. Fish and Wildlife Service tripartite Memorandum of Understanding for the Geothermal Program, signed June 1976.

Surface disturbances will be allowed without further cultural resources inventories within those areas already examined preparatory to this ES and found to contain no cultural resources (see Figure 2.10.2-1).

1. No surface entry will be permitted on the cultural resource sites known and those as yet to be inventoried that are defined as being of extremely high sensitivity (see Figure 2.10.2-1 and Section 2.10). These include rock art sites, aboriginal village sites, aboriginal cemeteries, certain rock shelters with associated occupational midden

and the Coso Hot Springs National Register site. The sites presently known to be included in this category are: ERG-253, 268, 273, 313, 316, 340, 373, 375, 380, 381, and DA-3, 9, 12, 28, and 35. Additional rock shelter sites within the proposed Fossil Falls Archaeological District (not within sample units examined in the present survey) should be reexamined for major occupation debris or fragments of rock art; these sites may also be worthy of complete avoidance. No further mitigative measures, other than monitoring (see Mitigation Measure 5 below), will be required at the sites listed above.

Cultural resource sites yet to be discovered which appear to be of extremely high sensitivity will be evaluated by the SHPO in order to develop and implement adequate site-specific mitigation measures.

2. No surface disturbances will be permitted on all other cultural resource sites determined to be eligible for inclusion on the National Register, and those yet to be inventoried, until the National Advisory Council on Historic Preservation has been afforded a reasonable opportunity to comment and until concurrence on appropriate mitigation measures has been obtained from the SHPO. Until such concurrence is reached, total avoidance of the cultural resources will be the only allowable mitigation measure.

3. After leasing, the following Cultural Resources Assessment Strategy will be fully developed and implemented in consultation with the SHPO, to provide an evaluative standard whereby the potential data yield of aboriginal lithic scatters both known and yet to be discovered by lessee-funded archaeologists can be assessed.

   The Cultural Resources Assessment Strategy will comprise the following steps in order to penetrate the obsidian "masking effect" and allow further appropriate mitigation measures for impacts to lithic scatters within the CGSA to be developed and implemented:

   A. Develop a detailed research design (including field methodology) to achieve, at a minimum, the following objectives:

      1. Inventory at least eight transects radiating outward in equal intervals from Sugarloaf Mountain. Each transect will be 50 meters wide and extend to the boundaries of the CGSA. Record all sites encountered along each transect. Conduct a limited surface collection of every lithic scatter inventoried within each transect and excavate up to five subsurface units within those lithic scatters that appear to require a subsurface sample for adequate evaluation of the resource.

         Surface collection and possible subsurface data recovery could provide valuable information showing variability and attenuation of archaeological materials at different distances from Sugarloaf Mountain. Future sites encountered by lessee-funded archaeologists at similar distances from the obsidian source could then be effectively evaluated by the BLM and the SHPO for their potential to yield significant data.

2. The field methodology, inventory, laboratory analysis, and reporting to the results should collectively provide data to:

   A. define the local chronology, based on inter-site and intra-site analysis of flaked stone artifacts, obsidian hydration studies, and other appropriate relative and absolute dating techniques;

   B. provide an initial understanding of local aboriginal subsistence and lithic exchange systems, based upon analyses of flaked stone tools and projectile points, lithic use-wear, flake-core ratios, and obsidian sourcing. Studies of exchange systems should emphasize the Great Basin-Coso, Kern River-Coso, and Coast-Coso trade relationships; and,

   C. generate a diachronic land-use model, based upon inventory and data recovery results and propose a methodology for testing the hypothesis.

B. The results of the data analysis will then be provided to the responsible BLM archaeologist, the NWC, and the SHPO. The report results will provide the necessary evaluative standard whereby the potential for other lithic scatters (inventoried by lessee-funded archaeologists) to yield significant scientific data could then be evaluated by the SHPO. The BLM, NWC, and SHPO, in consultation with one another, will then develop and implement any further necessary mitigative measures for those lithic scatters determined to be eligible for inclusion on the National Register and which may be impacted by geothermal development.

C. The cultural resources inventories and reports prepared by the lessee achaeologist(s) as part of the Plans of Operation submitted to the USGS must conform to BLM standards and incorporate the objectives of the Cultural Resources Assessment Strategy.

It is anticipated that the implementation of the Cultural Resources Assessment Strategy will, in large measure, provide the required mitigation for most of the extensive lithic scatters that may be impacted by geothermal development. Not only will the Assessment Strategy upgrade the present knowledge of the cultural resources within the CGSA in order to facilitate compliance with Section 106 of the National Historic Preservation Act of 1966, but it will also provide a mechanism to prevent unacceptable data loss which may result from separate surveys, piecemeal excavations, and disperse sampling of site-specific areas proposed for development by various lessees.

Important to efficient geothermal development, the plan should reduce the necessity for future in-depth site-specific investigations of aboriginal lithic scatters. For example, on the basis of the results from the Cultural Resources Assessment Strategy, it should be possible to state that a specific lithic scatter (located at an area proposed for geothermal development) appears typical of others of its type and distance from the obsidian source, already examined. In such a case, it is possible that sufficient data from similar sites and/or site types within the CGSA have been previously recovered and studied, rendering further data recovery redundant.

4. Section 18 of the Geothermal Standard Lease Form is extremely pertinent to the proposed action in the Coso Geothermal Study Area and must be highlighted as a special stipulation.

5. Periodic monitoring by site inspection and photo documentation of certain cultural resources will be conducted by the BLM and NWC authorized personnel. If degradation of the cultural resources is found to occur, particularly as a result of geothermal development activities, including vandalism, the BLM and NWC will develop appropriate mitigation in consultation with the SHPO.

6. A cultural resources educational program, sponsored jointly by the BLM and NWC, will periodically be presented to the lessee and their personnel. Such a program will be designed to inform the geothermal lessees, and their personnel and families of the fragile nature of the cultural resources with the CGSA, the mitigative measures that are being implemented, and the legislative restrictions and prohibitions toward collecting cultural resource materials. The general public will also be invited. This measure should help reduce pothunting by uninformed individuals related to the geothermal development program.

7. The BLM Rangers will increase patrol of the public lands to help prevent vandalism.

3.10 MITIGATION OF LAND USE IMPACTS

1. Coso Road, which presently passes through the Prayer Site, should be rerouted to the south, as suggested in the NWC Final ES, 1979. The responsibility for this should lie with those lessees who must use this road segment for access. This should include the NWC geothermal development contractor.

   Indirect land use impacts caused by pressure to develop support and service facilities in the event of extensive development in Rose Valley would also have to be mitigated; see 3.11 below.

2. Any leases which include portions of Wilderness Study Area 157 will include the protective stipulaton in the USDI, BLM publication of Dec. 12, 1979, entitled "Interim Management Policy and Guidelines for Lands under Wilderness Review".

   These stipulations require that activities may be permitted so long as the BLM determines that they will not impair eventual wilderness suitability. Activities considered suitable must:

   1. Be temporary

   2. Permit reclamation

   3. Assure that the area's wilderness suitability is not impaired upon termination of the activity.

3.11 MITIGATION OF SOCIOECONOMIC IMPACTS

1. Developers will be required by USGS to supply employee transportation to and from work sites. This mitigation is discussed in other sections of this chapter. It is anticipated that the measure would reduce disturbance experienced by Native Americans during ritual and religious activities at Coso Hot Springs and the Prayer Site.

2. Siting of a Class I or Class II-I disposal site in the vicinity of the CGSA should be required to reduce cost, transportation impacts, and potental for accidential spills during long hauls involved in hazardous waste disposal at Covina, Elk Hills, or Taft. New roadway geometry should be provided to avoid congestion at Coso Junction due to turning of slow-moving, heavy vehicles.

3. Formation of Native Indian Patrols for protection of petroglyphs or

other extremely-high-sensitivity areas (as suggested by the Paiute Warriors' Association and the Owens Valley Elders) should be encouraged. Any patrolling within the NWC boundaries must be an NWC management decision.

4.0 UNAVOIDABLE ADVERSE IMPACTS

The material in this chapter describes those impacts which would remain after mitigation if the proposed action described in Chapter 1 is implemented.

4.1 AIR QUALITY

Ambient fugitive dust concentrations will be increased above current levels by geothermal development. The principal emission sources will be vehicle traffic on unpaved roads, grading and construction activities, and wind erosion of exposed areas. The impacts will, for the most part, be localized to the development area. The magnitude of the ambient dust level increase will be determined by the degree of mitigation. Appropriate application of mitigation measures, particularly watering of unpaved roads, should make it possible to maintain 24 hour average ambient levels below 100 ug/m3, which is within all government TSP standards.

Ambient gaseous pollutant levels will be increased, primarily by power plant operation and well testing, but also by vehicular activity. The most significant increase will be in the concentration of hydrogen sulfide. Ambient levels of hydrogen sulfide in the vicinity of geothermal development may increase up to, but probably not exceed, the state one-hour average standard of 30 ppb.

The local visual range will be decreased by elevated ambient dust levels, the amount of decrease being determined by the degree of mitigation applied. Under worst-case conditions the visual range as observed from the CGSA would be expected to decrease from its present annual mean of 61 miles to approximately 51 miles. With appropriate mitigation (such as watering) visual range should not decrease perceptibly (only one or two miles at the most). Visibility degradation due to fugitive dust from the CGSA should not interfere with the NWC mission because particle deposition will tend to confine elevated TSP levels to the immediate area. Regional visibility will decrease no more than 10 percent in the worst case if hydrogen sulfide emissions are at the levels projected and if mitigation measures are applied as necessary.

Infrared visibility should not be significantly impacted by the predicted upper level ambient level increases of 0.2 percent and 2.0 percent for carbon dioxide and water, respectively. The NWC mission should not be affected by this increase.

4.2 NOISE

Noise levels in some sections of the CGSA will increase as a result of geothermal development. Increases occurring along access roads and near power plants which result from electrical power production will be permanent thoughout the productive life of the geothermal field. Maximum instantaneous noise levels adjacent to roadways will be approximately 90 dBA, and near power plants will be about 70 dBA. Temporary noise level increases resulting in ambient levels of up to about 80 dBA will occur in the vicinity of construction sites. The degree of increase will depend upon the distance of the receptor from the noise sources, the presence of noise barriers (e.g. mountains or ridges) between source and receptor, and the amount of mitigation imposed. Certain mitigation measures (e.g., elimination of truck traffic at night) would reduce Ldn and CNEL levels, while having no effect upon Leq levels.

Specific residual impacts can be addressed in terms of sensitive receptors. Power plant construction and operation workers will be exposed to highly elevated noise levels during their work hours, up to around 100 dBA for the operation of heavy equipment such as tractors and pile drivers. These levels can be mitigated so as to meet health and safety standards, but many activities will still be audible to nearby workers. Coso Junction Rest Area users will be subject to vehicle noise up to 90 dBA from the Coso Junction access road which intersects U.S. 395 adjacent to the rest area. There should be no unavoidable adverse impacts upon other sensitive receptors in Rose Valley (e.g. Rose Valley Ranch) unless a power plant is constructed within 1.5 miles of the receptor. When mitigation measures are strictly imposed, there will be no residual noise impacts to Native American religious observances at Coso Hot Springs and the Prayer Site, so the present background level of approximately 40 dBA should be preserved during religious usage periods. Finally, geothermal activities will be audible to wildlife no matter where the power plants are located because various species live in all sections of the CGSA. Mitigation measures can reduce the noise impacts upon particularly sensitive wildlife areas such as raptor nesting sites.

4.3 GEOLOGY

Although it is considered highly unlikely, the only unavoidable engineering geologic hazard is possible well damage due to subsurface fault movement or ground shaking. If such damage does occur, the impact to soils and vegetation due to salt buildup could be moderate to severe and would include leakage from ruptured well casings to total blowout.

As there is no statistical basis for prediction of such events, further quantification of such impacts is not possible.

4.4 HYDROLOGY

The identified unavoidable impacts in this resource area are:

1. Lowering the water table in Rose Valley. This will occur if long-term ground water withdrawal exceeds natural and artificial recharge. The quantity of usable ground water in storage and underflow to Indian Wells Valley will be reduced. The underflow is a very small percentage of the total Indian Wells Valley recharge, and should not impact users of the Indian Wells Valley ground water. The spatial distribution of water types may be altered to an indeterminate degree.

2. Degradation of natural ground and surface water. This would most probably occur only as a result of an accident, such as a well blowout or leak in a surface facility. Degradation due to most accidents would be short-term and local. Blowouts may be more difficult to control and could contaminate larger areas.

3. Alteration of flow to Coso Hot Springs. Mitigation measures that would totally reproduce natural flow may be unacceptable to Native Americans. It is not known whether the alteration would be permanent or temporary.

As indicated in Chapter 2 and in the Hydrology Technical Report studies are presently being conducted by USGS to identify the aquifer flow patterns in order to obtain a better understanding of the recharge in the area. Until such data becomes available, quantification of the residual impacts is not possible.

4.5 SOILS

Some adverse increases in soil erosion and sedimentation will occur due to soil disturbance associated with all stages of geothermal development before soil stabilization has been achieved. Such construction impacts are generally considered short term.

Although unlikely, blowouts, mud sump, or reserve pit failure or overflow may occur. Assuming a best-case scenario a blowout may occur but is quickly brought under control with no resultant damage to the sumps and minimal amount of geothermal effluent spills on the soil surface. The impact of such an accident would be localized and insignificant provided the proper mitigation actions are rapidly implemented. In a worst-case scenario, a blowout may occur and continue unabated, the duration of the incident being dependent on a number of factors, such as depth of the blowout in the well casing. Impacts to soil resources should this even happen are described in Section 2.6.2. A blowout may spread fragments on the soil surface around the drilling pad, and geothermal fluid may escape to the soil surface and possibly contaminate the soil with its constituents. The degree of soil contamination is dependent on the exact composition of the geothermal effluent, but a build-up of salts would occur. A severe blowout may possibly cause sump failure, which could result in further contamination of the soil with drilling muds and geothermal fluids. Sump failure may also occur independently of a blowout. The uncontrolled release of the full blow of geothermal fluids may also result in erosion of the drill site. These impacts are considered to be significant and localized, and the degree to which they occur will depend on the nature and duration of the incident.

Surface disturbance and the direct occupation of the land by geothermal related structures, facilities, and roads constitutes an unavoidable adverse impact, even if <u>all</u> mitigation measures recommended are implemented.

4.6 WILDLIFE

<u>Habitat Disturbance and Loss</u> - During the exploratory, drilling and construction phases, wildlife habitat will be lost even though such activities are carefully located on each lease tract. Mitigating measures to supplement the lost vegetation by replanting roadside cuts and other areas will offset a portion of the significant loss of habitat needed for foraging, nesting, and cover by wildlife species. It is impossible to predict the numbers of lizards, birds, or mammals which may no longer be able to inhabit the CGSA, since population density measurements were not made. However, to obtain an idea of the numbers of animals affected by a habitat loss of say 20 acres, the following figures are presented. In the five trapping areas (approximately 20 acres each), using 333 regularly spaced live traps for three nights (1000 trap-nights total), from 483 to 516 nocturnal rodents were captured per trapping area. Evenly spaced trapping samples only a small portion of the total population. The site-specific EA required for each lessee's Plan of Operations will provide additional population data; particular emphasis will be placed on the rare Mohave ground squirrel, as proposed in the Mitigation Chapter.

may be in conflict for EA on a POO

The wildlife community structure will be adversely affected by losses of vegetation. Animals most likely to be affected will be small mammals, herpetofauna, and small birds, which depend upon more restricted foraging areas than larger species. The species affected, and the amount and significance of their reduction, will depend upon exact facility siting, exploration, etc. Some 2,260 acres of vegetation would be lost (See Section 4.7), from the proposed action and the Navy Geothermal Program. A small amount of natural revegetation should take place on disturbed areas during the life of the proposed action, permitting partial recovery of wildlife populations.

After closeout, restoration would allow decompaction of soils and seed bed preparation to encourage plan succession (pioneer invading species, gradually replaced by long-lived climax plant species) on the bare soil and thus bring about general habitat improvement. Vasek, et al., (1975a), in a study on construction projects in the Mojave Desert, found that 30 to 40 years were required in the most optimal areas; they estimate at least 100 years would be necessary for Creosotebush Scrub communities to recover. However, since plant species recovery will be aided by implementation of restoration activities, recovery rates should be increased over those due to natural succession, and the numbers of invading weedy species could be kept relatively low. As plant habitat slowly reclaims the disturbed areas, wildlife populations would return to original levels. Provided the species are still viable.

Human Presence and Noise - Considerable noise will be generated by well drilling. If sensitive roosting and nesting areas are avoided, the principal impact will be that raptors, mammalian carnivores and probably other bird species will not use habitat within one-half mile of the drilling area. During the operations period, some species may return to the vicinity of the power plant.

Ground Water Lowering - If ground water is used in the quantities projected, Little Lake has a high probability of decreasing in volume and hence a valuable habitat for waterfowl and other wildlife species may be endangered.

Pipelines - Steam pipelines may impede some large animal movements, depending on location of lines height above ground, and configuration of expansion bends, e.g., whether vertical or horizontal.

4.7 FLORA

Devegetation - During the construction process, 2,260 acres of bare and/or level ground will be required and thus the vegetation will be lost. Types of vegetation lost would depend on location of exploration and development activities, but all vegetative associations in the study area are relatively common. Joshua Tree Woodland is of higher value for wildlife habitat and scenic qualities, but its distribution is not in the areas most likely to be disturbed. Because of its value as wildlife habitat, it will be protected by mitigation. Unique plant species and CNPS species will be protected by mitigation.

Trampling - Vegetation will be disturbed and trampled by field crews and off-road vehicles during the exploratory phase and during construction of transmission lines. Vasek et.al (1975) found that 13 years after construction of a transmission line in the Mohave desert, vegetation disturbances due to trampling were still evident beneath pylon.

4.8 VISUAL RESOURCES

If mitigation for VRM Class II areas recommended in Chapter 3 is implemented only structures which meet the Management Class restrictions will be allowed. These include pipelines, transmission lines, and the main switching yards. These will be visible in the Class II area, but if well designed, will maintain the overall esthetic pattern of the area.

4.9 CULTURAL RESOURCES

The CGSA appears to be of National Register significance on a regional basis. As outlined in Section 3.9, a mitigation plan and a Memorandum of Agreement are planned to be developed in coordination with the State Historic Preservation Officer and the National Advisory Council on Historic Preservation.

Despite mandated measures and the mitigation program outlined in Chapter 3, there will be unavoidable disturbance of some archeological material by accident. Geothermal program personnel will generally not be experienced in recognizing cultural material and may unknowingly destroy or disarrange deposits in sites near development areas by accidentally driving or walking over them. A possible total of 2,150 acres of surface disturbance would result from the proposed action; approximately half of that area could be predicted to contain archaeological sites.

If avoidance of a given site is not possible, some disturbance and data loss are inevitable. Reduction, but never complete elimination, of this data loss can be accomplished by data collection. If five percent of a site, for example, will be disturbed, by placement of a road, and all possible data are recovered from the impacted area, the residual impact will be less than five percent but never zero percent. The salvage and study of a portion of a site (compared to a study of the entire site) would yield data concerning only that portion, and perhaps at best enable some inferences about the whole, which may be corroborated or contradicted on the basis of further study. Disturbance or destruction of even a peripheral portion of the whole, however carefully the removed material is studied, is a loss of data concerning the whole, in an area as culturally rich (and as yet incompletely understood) as the CGSA.

A further unavoidable adverse impact is vandalism, particularly on those sites that have apparent surface scatter. It has been suggested that education of project personnel can minimize this; however, it seems realistic to suggest that some additional pothunting and general deterioration of the archaeological resource beyond present levels would be unavoidable with increased use of the area.

In summary, some sites will be avoided as a result of the measures taken; some will be salvaged. In the process of salvage, some data will be gained and some will be lost. The significance of this data loss cannot be determined in advance.

4.10 LAND USE

The only unavoidable adverse public land use impact of significance likely to accrue as a result of the proposed program is possible interference with Native American uses of the Coso Hot Springs and Prayer Site. While mitigation measures have been recommended, and an access agreement with NWC has been signed, occasional additional impediment to their usage of the sites due to geothermal development may be unavoidable. For example, religious observances at the Prayer Site may occasionally be disturbed by nearby development even if Coso Road is relocated, as suggested. A new land use would be added to the CGSA as a result of 2,150 acres of land diverted from present uses to geothermal development. The NWC mission should not be substantially interfered with, because the development activities will be required to work around the NWC activities.

4.11 SOCIOECONOMIC

Housing and Infrastructure - Population increases will create additional demands on all facilities and services of southern Inyo county and northeast Kern County. Zoning in these areas is designed to accommodate some change in private land use, e.g. from agriculture/grazing to residential/urban uses. However, influx of both temporary and permanent workers may pose the need for acceleration of these changes beyond the rate presently provided, necessitating policy decisions by both Counties.

Public Fiscal Impacts - Although revenues from the proposed program, including sales tax subventions and sharing of geothermal revenues with the State, should eventually mitigate the public fiscal burdens imposed by the need for additional infrastructure, these revenues may not accrue sufficiently early in the development program. Floating of bonds may then become necessary. This bonding, if it approached the limits of the jurisdictions' bonding capacity, might then preclude the implementation of other necessary capital improvement projects.

Fresh Water Availability - Additional drawdown of water in Rose Valley for geothermal and domestic uses, and in Indian Wells Valley for domestic uses occur.

Vehicular Traffic - Even with mitigation, increase in vehicular traffic up to a possible 1,000 additional vehicle trips per day on Highway 395 and within the CGSA will inevitably accompany geothermal development, with consequent potential for congestion at Coso Junction.

Native Americans - The potentially unavoidable adverse impacts on Native Americans wishing to preserve and utilize these areas are addressed in a number of sections above.

monitoring will not aid in wildlife recovery

5.0 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USE AND MAINTENANCE ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Implementation of the program would result in some lowering of wildlife populations by direct (fatalities) and indirect (habitat loss) impact as discussed in Chapter 2. The lowered productivity of the CGSA as a whole, and the disturbance of ecological relationships -- as for example, predator-prey balance and changes in habitat due to introduction of exotic plant species -- would result in long-lasting effects, persisting beyond the assumed 50-year span of the program. Wildlife species of particular concern during this period would be the rare Mohave Ground Squirrel, raptors such as the prairie falcon and golden eagle, and carnivores. However, within a few decades after close-out, with proper mitigation, monitoring and restoration, wildlife populations, including the species mentioned, could recover to their preconstruction levels. Without such measures, recovery would take hundreds of years (Vasek, *et al.*, 1975a).

In the short term, i.e., for the assumed 50-year life of the program, biological productivity of the CGSA would undoubtedly be lowered by the loss of some 2200 vegetated acres. Most of the perennials in the CGSA are long-lived, very slow-growing plants. The rare cord grass (*Spartina gracilis*) (rare, CNPS) could become locally extirpated if the water level of Little Lake is lowered by depletion of the water table. The rare poppy (*Canbya candida*) and pholisma (*Pholisma arenarium*) (rare, CNPS) are restricted to very small areas and could be also lost if care is not taken to avoid their habitat areas. Without restoration efforts, plant communities damaged would take centuries to recover. With proper mitigation measures, discussed in Chapter 3, the general level of vegetational productivity could probably be partially restored within a few decades (Vasek, *et al.*, 1975a), though rare or limited-distribution species may be irreparably damaged or lost. Changes in soil structure, discussed in Section 2.6, would alter plant habitats. Another long-term vegetational change can be expected as a result of the accidental introduction and spreading of exotic weedy species such as Russian thistle. Such changes -- loss of species, modification of soils, and addition of new species -- would persist indefinitely, though their extent may be limited by careful planning.

One possible long-term beneficial change, mentioned in Section 2.7.2, is the occasional enrichment of vegetational communities, under transmission lines and along unpaved access roads (Johnson, *et al.*, 1975); Vasek, *et al.*, 1975b).

Combined NWC and BLM development activities will have some inevitable immediate impacts on archaeological resources as discussed in previous chapters, except where avoidance of sites is possible through planning. These impacts may be short-term, for the life of the program (as in the case of portions of sites buried under gravel road surface but later accessible in large part after restoration) or permanent (as in the case of destruction by cutting through a site where only a representative sample of the data has been collected).

A short-term commitment of approximately 2.9 percent of the present CGSA area (2150 acres for 50 years) would be required for implementation of the proposed leasing and development program. Most of the present multiple uses -- grazing, wildlife habitat, watershed, mineral resources reserve, and use as a safety and periodic testing area for the NWC testing program -- could continue in general as at present on undisturbed portions of the CGSA. Present usage, by Native American groups, of the National Historic Register Site, including the prayer site, may be subject to interruption or disturbance unless appropriate mitigation is implemented.

Assuming eventual closeout and restoration (and assuming that appropriate mitigation and monitoring plans have been in effect), disturbed portions of the land within the CGSA could be returned to their present uses after about 50 years, with the possible exception of some roads. Where road construction has involved extensive cut-and-fill operations and/or blacktopping or other hard surfacing, effects could persist for, conceivably, hundreds of years (or require considerable regrading and removal of surfacing). Any additional roads left in place after closeout of the program would not substantially interfere with any of the above listed multiple uses; however, they would constitute an added attraction for sightseers, pothunters, and others.

Indirect land use changes (outside the CGSA) involving any residential or infra-structure construction in areas now devoted to agriculture, grazing or other uses would represent an opportunity loss, in that those land resources would not be available for their present uses. Some such changes (e.g., shopping and service facilities and residential developments) would probably have been incorporated into the general growth patterns of the region by the year 2030, with or without the proposed geothermal program.

In the short term, the program would require the commitment of large amounts of labor (building up to a maximum of possibly 500 employees over a period of several years), materials and funds (an estimated $2 billion, in 1977 dollars, for total payroll and materials over 50 years). The benefits accruing from the program would include the production of 550 MW of electricity at full development; this would result in the sale of approximately 3.85 million MWh/year at an average adjusted retail cost (for all uses) of $40 per MWh, or total sales of $154 million per year at full production in 1977 dollars (California Energy Commission, 1978). This assumes 80 percent capacity.

Other economic benefits of the program in the short term include the generation of direct and indirect employment and stimulation of the regional economy in terms of payroll spending, sales tax subventions, new housing construction and new service industries.

The future of the region would thus be affected during the life of the program and beyond. The overall long-term effect would be to accelerate ongoing regional development. Some inevitable changes in life style would accompany the economic changes -- local population increases, land use changes, and some loss of the sense of remoteness and privacy heretofore highly valued by many of the region's residents.

In particular, some loss of privacy may be experienced by Native American groups wishing to visit the Coso Hot Springs and prayer site areas within the CGSA during the life of the program. Any alteration in the flow, temperature or characteristics of the Springs and muds, as addressed in Section 2.5.2, would be a long-term loss.

6.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Irreversible or irretrievable resource commitments are presently not possible to define. It is likely that the geothermal resource will be irretrievably depleted, but the extent is not known. It is possible that the Coso Hot Springs may be irreversibly altered, but it is also possible that, if they are altered, they may recover after production ceases. Ground water may or may not be irreversibly degraded. As long as total ground water use continues in excess of recharge the use will be an irretrievable commitment of this resource. Any time recharge exceeds use, ground water in storage will increase.

Commitment of biotic resources to the program is not entirely irreversible. Some loss of wildlife would be inevitable if the program is implemented, but populations would eventually return to original levels, as discussed in Chapter 5. Change in habitat, however, may be permanent.

Some vegetational changes resulting from the program, while not completely irreversible, would persist for perhaps hundreds of years even with careful restoration measures. Modification of soils (with inescapable consequences for plant life) is one such change: the rates of soil formation in desert areas are very slow, measured in centuries, and impoverishment of soils by wind and water erosion, spilled toxic materials, grading and compacting could leave soils and vegetational scars persisting long after the closeout period. Introduction of weedy species may result in additional permanent ecological change. Local extirpation of rare or limited-distribution plant species could be irreversible; attempts at re-establishing such species from other areas may not be successful.

To the extent that archaeological resources are disturbed or destroyed, such impact represents a permanent loss, as for example if such resources should be used as landfill after some representative portion thereof has been retrieved for analysis. Burial of resources *in situ* renders them temporarily unavailable for future study; but after restoration measures are taken, the deposit may then be accessible, with the exception of surface disturbance caused by removal of the overburden.

As presently defined, the proposed action should create no irreversible or irretrievable loss or commitment of land resources, with one possible exception. In the event that the steam and thermal water flow of Coso Hot Springs were significantly and permanently altered as a result of geothermal fluid extraction , the significance of this area as a cultural/historical resource management site and as a religious/traditional healing site for Native Americans would be irreversibly and irretrievably lost.

Commitment of industrial resources is generally irretrievable, with the exception of capital investment recovery through sales and depreciation. In view of the current and increasing emphasis on conservation and resource recovery, some substantial salvage of construction materials after closeout may be made possible by technological advances during the 50-year life of the program. Labor commitment is irrecoverable.

Changes, if any, in the characteristics of the Coso Hot Springs and muds would be long-term and perhaps permanent.

7.0 ALTERNATIVES TO THE PROPOSED ACTION

The proposed action is to lease the CGSA for the purpose of geothermal development. Chapters 1 through 6 discuss the impacts of such development utilizing a specific model which assumes that a total of 12 electrical generation stations (including NWC development), each of approximately 50 MW capacity will be constructed. The material in this section describes alternative to the proposed action.

The specific alternatives considered are:

1. Offer no leases. This is the "no-action" alternative.

2. Lease all lands except those with significant surface conflicts.

3. Conduct partially deferred leasing in order to protect the cultural resources of the CGSA.

4. Lease with no surface disturbance on areas with sensitive resources.

5. Conduct a staged leasing program by level of development.

6. Defer leasing until a comprehesive geotechnical testing program can be carried out under the supervision of an appropriate Federal agency.

7. Require that all lessees enter into a "unitization" agreement wherein a single operator is responsible for the development of the field.

7.1 NO LEASING ALTERNATIVE

The consequences of taking no action with respect to leasing of the CGSA are:

1. The potential geothermal resource will remain undeveloped, with the exception of the NWC geothermal project.

2. The lands will not be disturbed by exploration or development.

3. Data and information concerning the nature of the resource will be forgone unless the government sponsors seperate exploratory activities.

4. The lands would remain available for leasing at a later date.

5. The existing uses would continue, undisturbed.

Impacts of not leasing include potential increases in the degradation of air quality in various basins in the southwest United States due to combustion of fossil fuel for the generation of electrical energy which might have been generated with the Coso geothermal resource.

The CGSA, without implementation of the proposed geothermal development, is expected to remain much as it is at present with regard to wildlife. Two changes which would alter the existing environment to some extent are increased alfalfa farming at the Rose Valley Ranch, and hence increased pumping of ground water (see Hydrology, Section 2.5), and the proposed NWC geothermal facility on lands to which the Navy holds fee title near Coso Hot Springs.

Both these developments may lower ground water levels in Rose Valley and could affect the riparian habitat and aquatic species at Little Lake (NWC 1979). Haiwee Spring, which derives water from the north and east of the CGSA, probably will not suffer from lower flow as a result of the NWC geothermal development.

Some terrestrial habitat loss will occur in the vicinity of the Navy fee-owned lands, as a result of disturbance for drill pads, sumps, reserve pits, and power plant construction. A total of approximately 110 acres may be required for the NWC facility. Some wildlife habitat will thus be lost, and burrowing animal populations may be reduced in particular; but since vegetative cover is sparse in the Coso Hot Springs area, near which NWC development is expected, the impact to reptiles, birds and non-burrowing mammals due to habitat loss will probably be minimal (NWC, 1979: 188 pp.).

The presence of exploration and drilling crews and construction personnel will also affect wildlife. The noise of vehicles and equipment, and the presence of large work crews, will disturb foraging activities of raptors and mammalian carnivores. Once power plant operation begins, these disturbances should decrease, although some noise and human presence will continue and will displace certain wildlife species. If the proposed action is not implemented, the vegetative cover of much of the CGSA will remain essentially as it is at present.

As remarked in Section 2.7.2, future drawdown of groundwater in Rose Valley for increased agricultural acreage and for the NWC geothermal installation could seriously affect Little Lake by lowering water levels. The effect might be to increase marshland vegetation at the expense of water surface, and, hence, habitat for aquatic species and waterfowl; eventually if deficit drawdown continues, the marshland might also be lost.

Even if leasing does not occur, approximately 110 acres of Navy fee-owned land, mostly in Geothermal zones 1 and 2, will be disturbed for exploration, drilling, and construction of geothermal plants and associated facilities. The areas within Zones 1 and 2 which may be disturbed are largely covered with creosote bush associated with burro weed and mixed desert scrub, all of which are common throughout the CGSA; therefore these cannot be considered as sensitive areas with regard to vegetation.

Even if the proposed development is not initiated, it cannot be assumed that archaeological resources within the CGSA will remain at the state in which they were discovered in 1978. Such resources are by their nature very fragile, and subject to deterioration from natural environmental conditions. Rainfall, water run-off, wind, freezing and thawing, erosion, and animal and human traffic contribute to disturb and disrupt the integrity of archaeological deposits. In 50 years it can be assumed that these natural factors will erode and deflate portions of midden deposits, relocate surface artifacts, and destroy and alter certain archaeological materials. If development is restricted solely to NWC lands these natural disturbances, of course, will not be halted. Further impacts, in such a case, will be restricted to the direct pacts resulting from increased human traffic in the area. The degree of indirect negative impacts resulting from the construction of the NWC facility will be contingent upon the amount of cultural resources education and supervision given to exploration, plant construction and maintenance personnel. It is very possible that, even with some educational program emphasizing the significance of cultural resources, in 50 years the archaeological sites within the immediate vicinity of the geothermal plant will be stripped of all identifiable surface artifacts. Thus, it can be conjectured that in 50 years those archaeological sites surrounding locations of geothermal development will be seriously impacted unless steps are initiated to mitigate these impacts prior to exploration and construction.

Unless there are significant changes in present land management policies and plans on the part of agencies governing land use within the CGSA (most notably BLM and NWC), future uses over the probable life of the proposed action (50 years) are not expected to be appreciably different from those found at present. Completion of the CDCA Master Plan by September 30, 1980, will provide some indication of the probable and permitted future uses, both for the CGSA and the surrounding region (BLM, 1977: 1-3). Because the California Desert Plan is only in preliminary draft stages at this time and presents three vastly different land use alterntives for the CDCA, it is difficult to speculate on the most likely ultimate plan (Pfulb, 1979). NWC land uses within the CGSA are not likely to change in the foreseeable future (NWC, 1977) with the notable exception of the Navy's proposed Coso Geothermal Development Program; this project is described in detail in the Navy's Programmatic Final Environmental Impact Statement (NWC, 1979). There is also a possibility that additional cultural resources may be nominated or determined eligible for inclusion in the National Register of Historic Places as a result of discovery and evaluation of sensitive archaeological areas throughout the CGSA (see Section 2.10). Although the CGSA is in proximity to the Los Angeles metropolitan area, no increase for recreation purposes is anticipated as long the the NWC and LADWP withdrawals remain.

Probably most land use changes which take place during the next 50 years will occur on the limited (1710 acres) privately owned land within Rose Valley. Among the more likely changes and developments are: expansion of agricultural lands to include greater alfalfa and field crop acreage (Hennis, 1979; Lane, 1979); possible development of geothermal resources, especially those from low-temperature fluids (Minor, 1979; Hennis, 1979); possible abandonment of the Lone Pine Branch rail line by Southern Pacific (Hebb, 1978); the draining of Lower Haiwee Reservoir and reallocation of DWP land uses in the area (Kuebler, 1978); the possibility of residential or commercial development at Dunmovin (Cooper, 1979); and the immediate expansion but ultimate abandonment of pumice mining operations at the Donna and Gill deposits at the North end of the CSGA (Paul, 1979).

Population projections to the year 2030 for Inyo County, Lone Pine Census Division, Lone Pine (unincorporated), Indian Wells Valley and the China Lake/Ridgecrest area are shown in Table 7.1-1. Within

TABLE 7.1-1

Population Projections for the Study Area: 1980 - 2030

Year	Inyo County	Lone Pine Division(3)	Lone Pine(4)	Indian Wells Valley	China Lake/ Ridgecrest (C.T.53&54)	Rural Indian Wells Valley (C.T.55.01)
1980	18,100(1)	3,300	1,745	25,700(5)	21,900(5)	3,900(5)
1990	22,200(1)	4,330	1,690	29,100(5)	24,200(5)	5,200(5)
2000	25,800(1)	5,230	1,640	33,000(5)	26,500(5)	6,500(5)
2010	29,300(1)	6,100	1,590	36,500(6)	29,300(6)	7,200(6)
2020	32,700(1)	6,950	1,540	40,300(6)	32,300(6)	8,000(6)
2030	36,500(2)	7,900	1,495	44,500(6)	35,700(6)	8,800(6)

Notes:

1. California State Department of Finance, Population Projections for California Counties, 1975-2020, Series E-150, Report 77-P-3, Sacramento, California, Dec. 1977.

2. ERG projection, based on same grwoth rate as used by California State Dept. of Finanace for 2020 projection.

3. Projections for Lone PIne Division estimated as 25% of Inyo County's projected growth, 1980-2030; discussed with R. DeHar, Inyo County Planning Dept. May 1979.

4. Lone Pine population projected on the basis of the -3.1% population loss experienced between 1975 and 1979 and discussion with P. Farlander, Executive Director, Lone Pine Chamber of Commerce, May 1979.

5. Kern County Planning Dept., Population by Census Tract, 1960-1979-1977-1980-1990-2000, March 1979.

6. Based on Kern County Planning Staff population projections for 2000; uses growth rate of 1% for IWV (C.T.'s 53 and 55.01) and C.T.'s 53+54 combined; Inyokern is included in C.T. 55.01. Discussed with J. Folpmers, Kern County Planning Dept., May 1979.

the Kern County subregion, 2030 population is expected to be approximately double the 1977 figure, with increasing decentralization from Ridgecrest into currently unincorporated areas. Inyo County population is also expected to double, largely due to net in-migration (Inyo County Planning Department, 1978: 11). Greater growth is expected in Lone Pine Census Division, which may triple in population even without the proposed action, although Lone Pine itself is seen as declining without further economic stimulus. The NWC geothermal program would add a temporary stimulus of some 350 construction employees within southwestern Inyo County, and a permanent population of 150-175 persons (NWC, 1979: 215).

The Land Use Element of the Kern County General Plan, in conformity with state law requiring comprehensive long-range community planning, provides for a more orderly development of the northeastern portion of the County in the near future. Further expansion in Inyokern and Brown Road is expected (Kern County Planning Commission, 1973; City of Ridgecrest, 1977; Burns, 1979). Inyo County's General Plan is being revised and updated, with the Land Use Element expected in early 1980 (Budlong, 1979). If County and State population projections for the Inyo County portion of the study area are correct, comprehensive planning will be essential to accommodate the increase. Additional private land acquisition and development may be required. The expectation of 150-175 additional permanent residents as a result of the NWC geothermal program would act as a stimulus for such development.

Pending revision of the Inyo County General Plan, it is difficult to predict the future availability of housing within the Inyo study area. However, to accommodate the expected population growth (and the NWC personnel), more residential construction seems likely. This will presumably be located in or near existing settlements to take advantage of services and utilities. The trend toward construction expansion in the Kern County portion of the study area is expected to continue; in the near future, a new-housing completion rate of 250 per year is expected in Ridgecrest (Brummett, 1979).

Infrastructure would expand incrementally to meet the requirements of the growing population. Fresh water supply systems and wastewater treatment facilities would be the most critical areas for adjustments, particularly in Inyokern, Cartago, and Lone Pine. Expansion of solid waste disposal facilities in the study area is currently proposed by both Kern and Inyo Counties. With present enrollment in Sierra Sands Unified School District well below capacity, no need for new facilities is anticipated in the near to medium-term future, except for replacement facilities or additional neighborhood classrooms. Development of additional parks and recreational facilities in Ridgecrest will be necessary, with or without continued access to NWC facilities.

Assuming that recreational traffic will continue to increase, Caltrans has projected annual increases of 4.5 percent in average daily volumes on Highway 395 in the vicinity of the study area (California Department of Transportation, 1979: 4). The Department plans to upgrade additional sections of the road to four-lane divided expressway, both north of Dunmovin and south of Pearsonville. The continuance of railway service north of Pearsonville is now in question, and may depend on whether the Inyo County portion of the study region receives some economic stimulus. Improvements are planned for the region's airports at Inyokern, Lone Pine and Bishop.

Some economic projections for portions of the study area have been provided by SRI International for the California Desert Planning Program (USDI BLM 1978). According to these analyses, the desert area in general will neither acquire major sources of new water nor lose those it now has. It will, however, be difficult (even with the exercise of conservation and recycling of water) for the region to provide for expected growth. Military activities in the area are expected to remain at approximately their present levels, while recreational activities are expected to continue to grow and to pose management problems-- always assuming the availability of fuel. Agricultural expansion will depend largely upon introduction of new species of plants.

Personal income in the desert portion of Kern County in 1990, according to SRI (USDI BLM 1978: III-3_3), is expected to total \$440 million, up from \$335 million in 1980; by the year 2000 it is seen as \$620 million or approximately double the figure in the late 1970s. In the desert portion of Inyo County, income is predicted to rise from a total of \$19 million in 1980 to \$30 million in the year 2000.

Employment throughout the area is expected to rise faster than population, as the proportion of working age persons will be greater, and the percentage of women working will continue to rise (ibid.: III-4).

7.2 LEASE ALL LANDS EXCEPT THOSE WITH SIGNIFICANT SURFACE CONFLICT

This alternative would open all lands to leasing and development except those areas which have been identified as having resources extremely sensitive to development, see Figure 7.2-1. These lands include a compilation of sensitive habitat for wildlife, (Figure 2.7.2-1), rare plants, (Figure 2.8.2-1), and the cultural resources of extremely high sensitivity as shown in Section 2.10 (Figure 2.10.2-1).

Soils which are sensitive to disturbance have also been identified in this document. However, sensitive soils are not included in the leasing limitations under this alternative because protection of soils by avoidance is not necessary; mitigation can be effectively implemented prior to and during development.

The total acreage which would not be offered for lease under this alternative is low, approximately 5720 acres; the bulk is in areas outside of geothermal zones 1 and 2. The impacts to the known sensitive wildlife resources would be less than those which would occur as a result of the Proposed Action in that

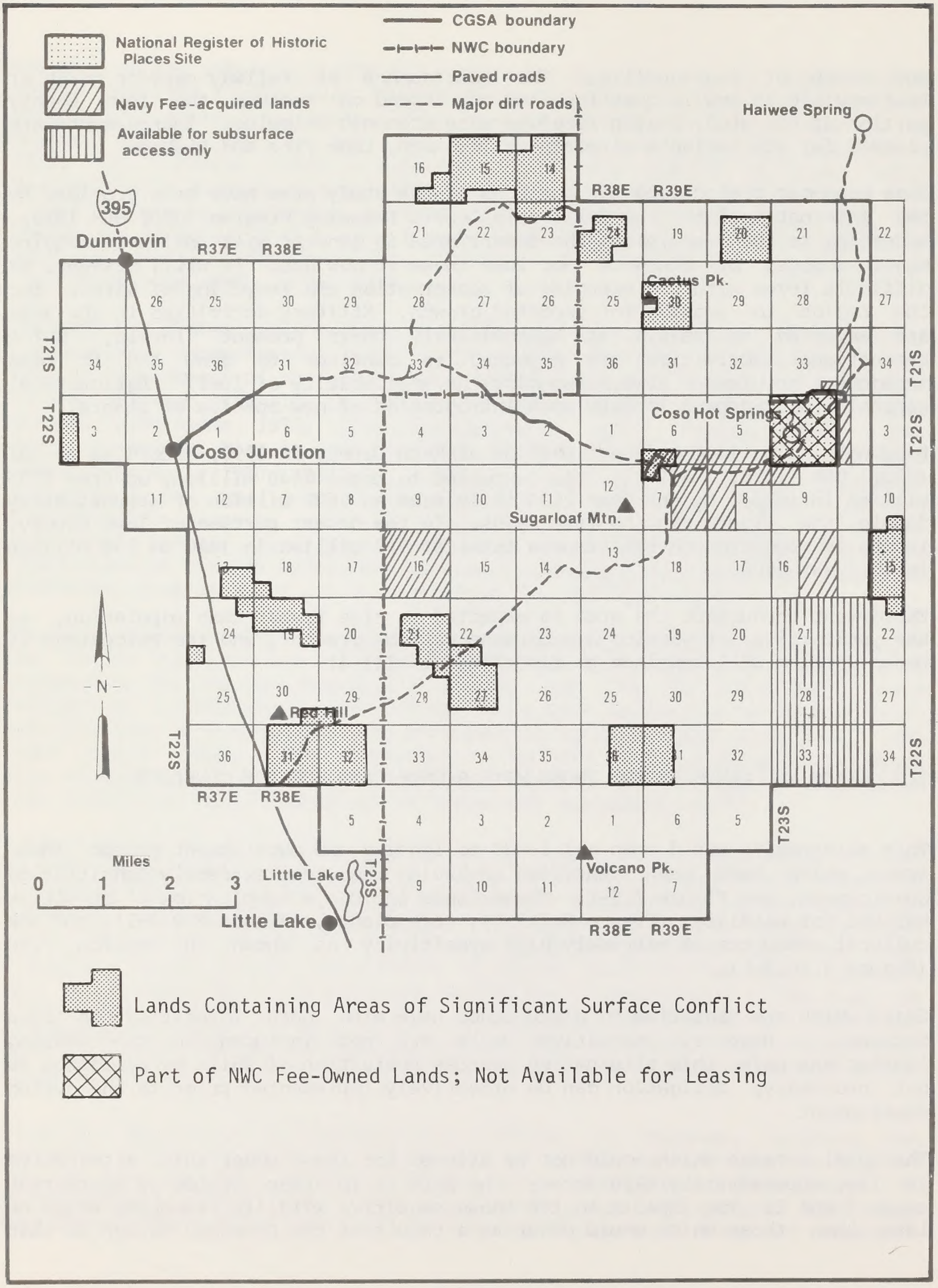

Figure 7.2-1. ALTERNATIVE 2: LEASE ALL LANDS EXCEPT THOSE WITH SIGNIFICANT SURFACE CONFLICTS

only carefully controlled surface entry would be permitted on those acreages not leased. However, the carnivore denning areas and adjacent high potential areas for raptor nesting on the rocky ridges would still be susceptible to noise, so a noise disturbance buffer zone of one-half mile would be needed for mitigation. It should be maintained around such areas until demonstrated to the satisfaction of the supervisor that the operations would not disturb nesting/breeding activities. Impacts to the known sensitive flora species and cultural resources of extremely high sensitivity identified in Sections 2.8 and 2.10 would not occur under this alternative because they would not be disturbed. All other impacts predicted (and not mitigated) under the proposed action would occur under this alternative.

7.3 PARTIAL DEFERRED LEASING TO PROTECT CULTURAL RESOURCES

This alternative would include the concept of partial deferred leasing in order to permit collection of sufficient data on cultural resources to determine optimal mitigation measures. Lands that would be open for leasing immediately would be those areas of the CGSA which have been inventoried and found to contain no cultural resources, roughly 6 percent of the CGSA (see Figure 2.10.2-1, areas labeled as "low sensitivity sample units"). The additional information which is necessary to collect and analyze is contained in Section 3.9 as the Cultural Resources Assessment Strategy. The deferral of the rest of the lands for leasing would probably be for a year or two, if the data collection was implemented concurrently with the initial lease sale.

The impacts of this alternative would be to limit the area leased; therefore the exploration to define the resource would be curtailed. Commitment of financial resources by the lessees for serious exploration might occur more slowly, because the area open for the initial lease sale may not give them sufficient geothermal resource potential to warrant large investments.

This effect on the initial availability of the geothermal resource would be large because it would defer the leasing of large portions of Zones 1 and 2. However, this would only be for a year or two, and then most of the CGSA could be leased with optimal cultural resources mitigation.

This alternative would protect the integrity of the cultural resources sites to the degree that no disturbance of sites would occur until after the addtitional data is collected and analyzed, and optimal mitigation is designed and concurred with by the State Historic Preservation Officer. Since the proposed mitigation which has been designed for the Proposed Action should protect cultural resources in a similar way, the degree of impacts from this alternative should be slightly less than those predicted to occur from the Proposed Action. Accidental disturbance would not occur, as it might under the Proposed Action if the proposed mitigation was not implemented immediately upon lease. Impacts of other resources would remain the same as from the Proposed Action.

7.4 LEASE WITH NO SURFACE DISTURBANCE ON LANDS WITH SIGNIFICANT SURFACE CONFLICTS

This alternative (Figure 7.4-1) would open to leasing all lands, but would require no surface disturbance of lands identified on Figures 2.7.2-1 and 2.8.2-1, and cultural resources identified as having extremely high sensitivity as shown in Figure 2.10.2-1.

The impacts to the identified sensitive resources would not differ from those predicted for the proposed action if the mitigation measures recommended in Chapter 3 are fully implemented. This alternative is, in a sense, the Proposed Action with mitigation applied.

The consequences of implementing this alternative are similar to those described in Section 7.2 with the primary difference being the potential to fully develop the field by utilization of slant drilling and careful selection of plant sites with respect to the sensitive resources. The primary impact of this alternative would be to marginally increase the cost of the electrical energy produced due to the requirement of more slant drilling. It would not, however, make unavailable any of the geothermal resource.

7.5 DEFER LEASING UNTIL COMPLETION OF FEDERAL TESTING OF THE GEOTHERMAL RESERVOIR

This alternative would result in essentially all of the impacts described for the unitization alternative. Such action would result in a more orderly exploration phase for the CGSA. A comprehensive exploratory program considering the geothermal resource as a complete entity would be designed and only the necessary surface disturbance would occur. There would be no incentive to perform exploratory activities on acreages not considered as being prime. This alternative would permit ready implementation of unitization as described below.

7.6 STAGED LEASING BY GEOTHERMAL POTENTIAL ZONE

The impacts of this alternative would be similar to those described for the Proposed Action. The principal advantage would be that only the "hot" zone would be initially explored and developed and there would, therefore, be less disturbance. Implementation would result in a longer period of development for the CGSA as a whole.

The first lease offering would be of Geothermal Zones 1 and 2 and make approximately 10,240 acres available. The size of the second and subsequent

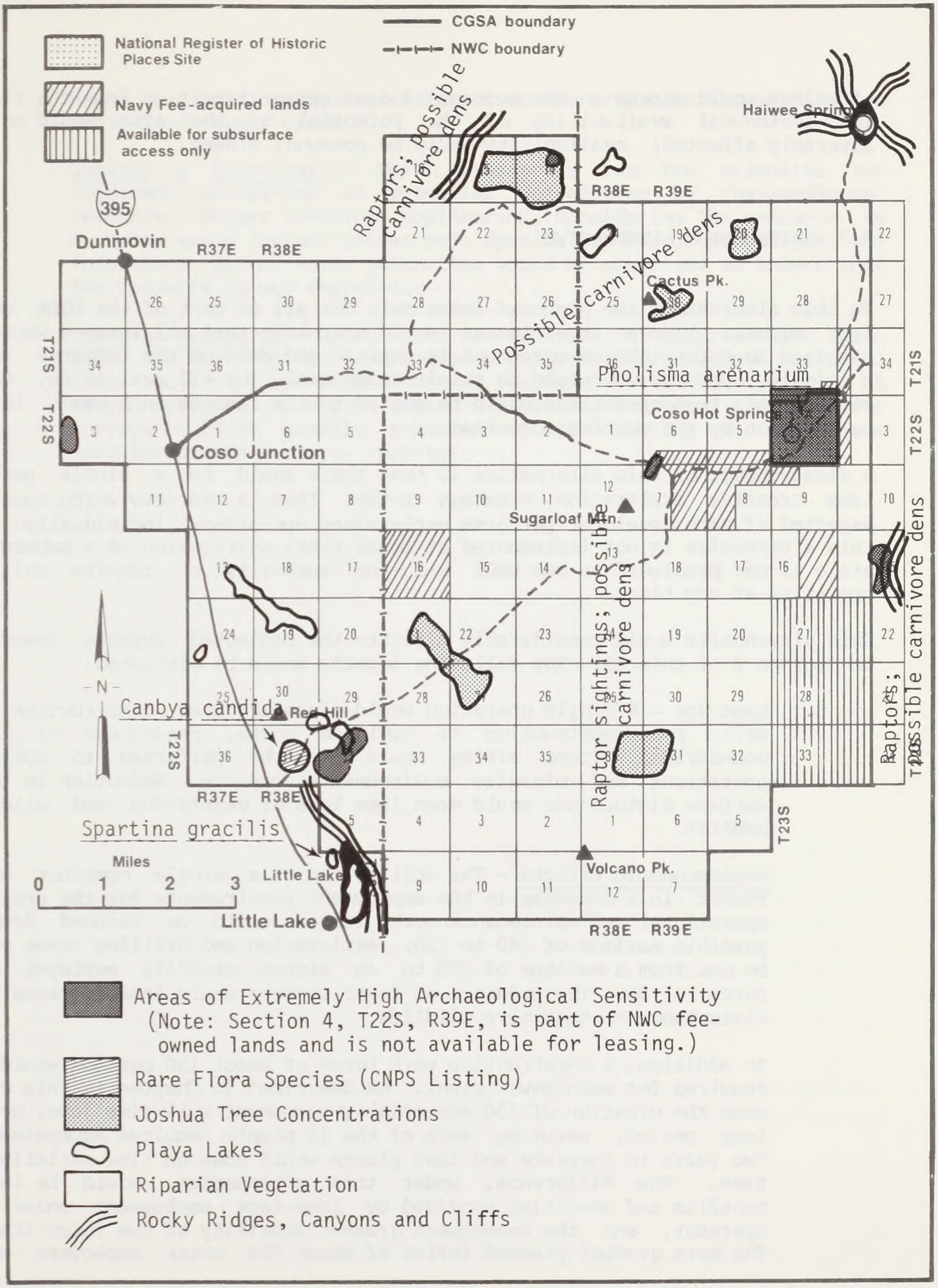

Figure 7.4-1. ALTERNATIVE 4: LEASE WITH NO SURFACE DISTURBANCE ON LANDS WITH SIGNIFICANT SURFACE CONFLICTS

offerings would depend on the success of development resulting from the first. The geothermal availability of the potential of the area would not be adversely affected; availability would be somewhat slowed.

7.7 UNITIZATION ALTERNATIVE

In this alternative the proposed lease sale for all or part of the CGSA would take place. However the leases would stipulate that all lessees would be required to enter into an agreement to explore and develop the resource using a single operator who would be solely responsible for all activities. Costs and Proceeds from operations would be shared by the lessees on a basis to be agreed upon by the parties concerned.

A disadvantage of this alternative is that there would be a single perhaps less creative exploration strategy rather than a variety which could be expected if each developer performs exploratory operations individually. If this alternative is not implemented at lease time, unitization at a subsequent stage is not precluded as the USGS has the authority to require unitized operation at any time.

This alternative would considerably mitigate the projected impacts described in Section 2 of this ES. The following impacts would be mitigated:

Land Use - A single operation would minimize road construction and well pad construction to optimize costs, regardless of lease boundaries. Plant siting would also be performed to optimize operations and minimize environmental impacts. Reduction in total surface disturbance would mean less loss of vegetation and wildlife habitat.

Socioeconomic effects - The utilization of a single operator would result in a decrease in the employment requirements for the project. Operational and maintenance work forces could be reduced from a possible maximum of 240 to 120; exploration and drilling crews could be cut from a maximum of 220 to an almost steadily employed work force of 50. The presence of fewer workers would itself create less disturbance to sensitive wildlife.

In addition, a construction work force of about 150 persons would be required for each power plant. As described in Chapter 1, this could mean the creation of 150 essentially permanent full-time jobs, over a long period, assuming each of the 11 plants requires approximately two years to complete and that plants would come on line serially in time. The difference, under this alternative, would be in the benefits and amenities provided by long-term employment under one operator, and the consequent greater stability of the force itself. The more gradual planned influx of about 300 total employees would have a significantly lesser impact on the area than the more random arrival of larger crews.

Geology & Hydrology - This alternative has the potential for signicant mitigation of potential degradation of the geothermal resource. Proper reservoir engineering, considering the resource as a whole, would include proper well spacing, drilling, production, and injection. Ground water extraction would be optimized to insure that the resource is not degraded.

Cultural Resources - Under this alternative a comprehensive plan could be developed, in advance of exploration, to locate roads and other facilities where artifactual deposits are not located. A staged program of direct impact mitigation, including site-specific surveys could be greatly enhanced by the ability to coordinate activities with a single operator.

8.0 CONSULTATION

The BLM decided to prepare an Environmental Statement (ES) by contract in late 1977. Coordination with the China Lake Naval Weapons Center, U.S. Geological Survey and other Federal, state and local agencies began during this time on both the geothermal program and preparation of the ES. Major participants in the coordination and information exchange process for the ES were the NWC, U.S. Geological Survey, California Energy Commission, and the State of California Coso Geothermal Advisory Committee, which is made up of most of the resource-related state agencies.

Concurrently, the Department of Energy awarded a contract to Lawrence Livermore Labs to prepare Overview Reports on the high priority Known Geothermal Resource Areas (KGRAs), including the Coso KGRA. The contract was sublet to the China Lake NWC. As a result, the NWC convened the Coso Advisory Committee in June 1978, including BLM, U.S. Fish and Wildlife Service, U.S. Geological Survey, California Energy Commission, Inyo and Kern Counties, the State Air Resources Board, Water Pollution Control District, and California Department of Fish and Game. The committee held three issue/impact scoping and planning meetings and then chaired a two-day public Coso Overview Workshop on August 17-18, 1978. The workshop was a multi-resource consideration and scoping of issues and impacts likely to occur from geothermal resource development at the Coso KGRA. It was very well attended and received by the public. Concerns brought up at this workshop covered a range of resources and have been addressed in this document.

Two public meetings were held by BLM and Rockwell November 15, 16, 1978 to acquaint the public with the proposed leasing program and upcoming ES preparation effort, and to receive any resource information which they could provide. These meetings were very poorly attended, although the attendees were receptive to the concept of geothermal development. The concerns expressed by the attendees at the Ridgecrest meeting centered on hydrology, while at the Lone Pine meeting concerns centered on Native American access to Coso Hot Springs, potential degradation of the springs, and whether leasing would restrict access.

During preparation of the ES, Rockwell and BLM conferred with various agencies and groups about methodologies of data gathering and impacts of the proposed leasing program. These included:

BLM/Owens Valley Paiute Shoshone Band of Indians - April 1978, covering Native American concerns.

BLM/Environmental Protection Agency/NWC/ Rockwell - November 1978, concerning air quality monitoring, modeling, impacts.

BLM/Air Resources Board/Rockwell - January 1979, concerning air quality monitoring, modeling, impacts.

BLM/Rockwell/Sequoia National Forest - April 1979, concerning schedule, and air quality impacts to the Forest.

BLM/Rockwell/Sequoia and Kings Canyon National Park - March, 1979, concerning schedule and air quality impacts to the Parks.

BLM/NWC/U.S. Geological Survey/Los Angeles Department of Water & Power/Rockwell - April 1979, concerning hydrology, existing environment, impacts.

Environmental Resources Group (subcontractor to Rockwell)/California Indian Legal Services, Owens Valley, Bishop, and Pauite Shoshone Tribe elders - June, 1979, covering Native American concerns about potential impacts to Coso Hot Springs and the Prayer Site.

BLM/U.S. Geological Survey/Rockwell - October 1979, concerning mitigation measures.

Other briefings on the project which were held included:

BLM's California Desert Advisory Committee - progress, schedule.

Inyo County - general, schedule, plans.

California Energy Commission - general, schedule.

California Coso Geothermal Advisory Committee - general, schedule.

Several unofficial coordination efforts were initiated with the State Historic Preservation Officer to receive interim guidance in development of proposed mitigation measures.

During preparation of this document, many agencies and individuals were contacted for information. Other general public affairs activities which have been carried out have been various special BLM District news publications, newspaper articles, and radio interviews to inform the public of the program and solicit information.

Reviews have been made during preparation of this ES and the supporting Technical Reports by various entities. The Coso Technical review team and other staff from the BLM, U.S. Geological Survey, the Naval Weapons Center, and certain experts on resource fields reviewed one or more of the draft Technical Reports. The interim draft submissions from Rockwell all were reviewed and approved by the BLM Coso Project Manager and the Technical Review Team.

The Draft EIS has been released for a public review period of 45 days. One public meeting will be held in Lone Pine approximately one month after distribution of the Draft. Reviewers are invited to comment at this meeting and by mail to the Bakersfield District Office of the BLM. The final ES will address these comments.

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APPENDIX A

REGULATORY CONSTRAINTS

A.1 INTRODUCTION

The influence of regulatory and institutional constraints is a major factor in the development of geothermal resources. Major consideration is given to land use policy and environmental protection. In addition, the development of the Coso Geothermal Resource is constrained by the requirement that development of lands presently withdrawn by the U.S. Navy does not significantly interfere with the mission of the Naval Weapons Center (NWC); see APPENDIX C. Although the leasing of public lands is strictly a Federal action, the actual development of the geothermal resource is regulated by Federal, state and local agencies. This section provides a compilation of those constraints which have been identified.

A.2 Federal Statutes

The Bureau of Land Management is responsible for the leasing of the geothermal lands and the U.S. Geologic Survey is charged with regulating operations on the leased lands. Additionally, USGS assesses the nature of the resource and classifies lands as, Known Geothermal Resource Areas (KGRAs). The BLM is the primary contractor with the USGS as a third party who has the conditional power to modify the lease. USGS also has the power to suspend operations and recommend termination of the lease. In other words, USGS controls the technical aspects of geothermal leasing, while BLM controls the administrative aspects of the lease. The BLM is responsible for monitoring for compliance with environmental protection requirements outside the operating area and the USGS examines operations to insure compliance. Both the BLM and the USGS regulations require submission of annual reports on the measures taken to comply with environmental requirements. The following is a list of Federal laws which potentially regulate and/or constrain the full development of the Coso Geothermal Resource.

<u>The Federal Land Policy and Management Act of 1976</u> (FLPMA) (Public Law 94-579). This act establishes Federal policy with respect to the utilization of Federal lands, their disposal, and the exploitation of resources contained on or under them. It designates the Bureau of Land Management as the agency

with primary responsibility for managing the public lands under the principles of multiple use and sustained yield, in accordance with the land use plans developed by the Bureau. This act joins the Wilderness Act (16 USC 1131-1136) and the Mining and Minerals Policy Act of 1970 (30 USC 21a).

The Taylor Grazing Act of 1934 (Public Law 73-865). This act authorizes the BLM to prevent injury to any public grazing land. It specifically calls for the prevention of overgrazing and soil deterioration, and directs the BLM to provide for the orderly use, improvement, development and stabilization of the livestock industry which may be dependent upon the public ranges. 43 CFR 4100. This regulation updates livestock grazing regulations for public lands, and adds provisions required by FLPMA of 1976. Essentially, this allows for management flexibility to achieve multiple use, sustained yield, and environmental as well as economic objectives.

The Geothermal Steam Act of 1970 (Public Law 91-581). This act provides for the leasing of lands containing geothermal resources. The law provides the Secretary of the Interior with authority to protect environmental qualities as well as promulgate leasing regulations. The regulations and related Geothermal Resource Operational Orders (GRO) mandate that Federal geothermal leases comply with all applicable Federal, state, and local environmental standards as well as any more stringent standards which the USGS Area Geothermal Supervisor may impose. This directive includes control of all forms of air, land, water and noise pollution, including but not limited to the control of erosion and the disposal of solid, liquid and gaseous wastes.

43 CFR 3200 - Definition of Terms.

43 CFR 3201 - Specifies lands available for leasing, limitations on leasing, and permits the establishment of unit operations. The section specifically waives the maximum acreage which any entity may control in a single state if leased lands are part of unit operations.

43 CFR 3203 - Specifies Leasing Terms.

43 CFR 3204 - Sets specific surface management requirements and sets limits on royalties and fees to be paid.

43 CFR 3206 - Specifies type of lease bonds required.

43 CFR 3209 - Establishes procedures for Geothermal Resources Exploration Operations on lands not specifically leased for geothermal development.

43 CFR 3210 - Establishes regulations for non-competitive leasing of land for geothermal development. Such lands are those which are not within a Known Geothermal Resource Area as defined in 43 CFR 3200.0-5.

43 CFR 3211 - Establishes procedures for release of formerly leased lands.

43 CFR 3220 - Establishes the procedures to be followed for competitive leasing of public land for geothermal development purposes.

43 CFR 3230 - Defines the rights to conversion of geothermal leases which have been issued under the Mineral Leasing Act of 1920 or subject to existing mining claims located on or prior to September 7, 1965.

43 CFR 3240 - This group of regulations establishes the rules governing geothermal leases. Included are rules pertaining to:

A. Assignments and transfers of lease rights.

B. Production and use of byproducts.

C. Establishment of cooperative or unit plans (unitization).

D. Terminations and expirations.

43 CFR 3250 - Provides the basis for the utilization of geothermal resources for the generation of electricity, by establishing a procedure for licensing electric power sites on geothermal resource leases under provisions of the Geothermal Steam Act of 1970.

30 CFR 270 - Establishes the authority of the U.S. Geological Survey (USGS) to regulate the development of geothermal resources on leased lands and to require compliance with the terms of the leases.

Establishes requirements for lessees (including operators). Requires the submission of drilling and producing plans as well as of well records and energy production records.

30 CFR 271 - Establishes regulations for unit operations.

Geothermal Resources Operations Orders

Geothermal resource operations orders are formal orders issued by the USGS to supplement the general regulations found in 30 CFR 270 by detailing the procedures and operations which must follow in a given area or region. The purpose of this arrangement is to allow consideration of more area-specific operating and environmental conditions.

GRO Order No. 1 - Exploratory Operations

GRO Order No. 2 - Drilling, Completion, and Spacing of Geothermal

Wells

GRO Order No. 3 - Plugging and Abandonment of Wells

GRO Order No. 4 - General Environmental Protection Requirements

GRO Order No. 5 - Proposed Report and Forms

GRO Order No. 6 - Pipelines and Surface Production Facilities

GRO Order No. 7 - Production and Royalty Measurement, Equipment and Testing Procedures

Federal Geothermal Leases

The Federal laws which are applicable to geothermal leases are two-fold because compliance with many of them is a condition of the lease. For example, the Federal geothermal leases require the lessee to dispose of toxic drilling muds and the containers in which mud additives are received in a manner approved by a USGS Area Geothermal Supervisor and in conformance with applicable Federal, state and regional standards. Also, the Federal Water Pollution Control Act (PL92-500) does not give EPA direct authority to regulate erosion/sedimentation control, but it is a function of the lease. Federal leases are limited in noise levels not to exceed 65dB at a distance of 660 ft. (201M). Note: these standards are higher than the currently enforced noise levels of the State of California. In general, the BLM/USGS regulations for geothermal leasing limits the amount of land surface a lease may utilize for geothermal production and disposal area.

Resource Conservation and Recovery Act of 1976 (Public Law 94-58). This act establishes the criteria for management of solid waste and waste products. It requires the promulgation of regulations which implements a permit system for the disposal of solid wastes. Initial regulations have been published in 40 CFR 240-247. The EPA has proposed rules under Sections 3001, 3002, and 3004 which, together with Sections 3003, 3006, 3008, and 3010, will constitute the hazardous waste regulatory program. It is the EPA's goal to integrate the regulations with the National Pollutant Discharge Elimination System required by the Clean Water Act, and the Underground Injection Control Program of the Safe Drinking Water Act. Specific guidelines are to be adopted in late 1979.

Clean Water Act (Public Law 92-500 as amended by Public law 95-217). This act establishes the national policy of protection of the nation's ground or surface water resources. It explicitly calls for the elimination of discharge of toxic pollutants.

A. 40 CFR 116 - Designates hazardous substances as defined in the Clean Water Act. In a recent suit (Manufacturing Chemists Association, et al. vs. Costle), it was decided by the U.S. District Court (Western District of Louisiana) which held that certain sections of the regulations are invalid. The status of this regulation is, therefore, in considerable doubt at this time.

B. 40 CFR 117-119 - States that the EPA no longer determines the 1) removability 2) harmful quantities 3) penalties imposed on the discharge of toxic pollutants.

C. 40 CFR 123 - Which requires state certification of activities requiring a Federal License or Permit.

D. 40 CFR 124 - Establishes the regulations on state program elements necessary for participation in the National Pollutant Discharge Elimination System.

E. 40 CFR 125 - Establishes the regulations on Federal programs similar to the NPDES program; however, geothermal development is not included. Control of new source pollution, in this case, is vested in NEPA, a carry over from the Water Pollution Control Act.

F. 40 CFR 149 - Establishes regulations on Review of Projects Affecting Sole Source Aquifers.

Historical and Antiquities Act (Public Law 93-291). This act empowers the Secretary of the Interior to provide for the preservation of historical and archaeological data which may be lost or destroyed as a result of Federal action.

A. 36 CFR 60 - Establishes the National Register of Historic Places

B. 36 CFR 800 - Specifies procedures for the Protection of Historic and Cultural Properties

The National Historic Preservation Act of 1966 (Public Law 89-665). This act enlarges the National Register to include districts, sites, buildings, structures and objects significant in American history, architecture, archeology, and culture. It permits nomination of such historic sites for inclusion into the National Register by the various states. Incorporated into this act is Executive Order 11593, which appoints and delegates responsibilities to the State Historic Preservation Officer, and provides for the State Historic Preservation Plan, and procedures for notification and nominations of sites.

The Clean Air Act (Public Law 91-604 and amendments). This act, as amended, establishes the Federal policy for protection of the quality of air and sets forth specific methods by which such protection shall be carried out. The law requires that each state prepare an Implementation Plan which clearly describes how that state will insure that National Ambient Air Quality Standards (NAAQS) are achieved and the significant deterioration of ambient air quality will be prevented.

The regulations designed to prevent significant air quality deterioration in areas where the air pollution levels are currently below the NAAQS (source-specific) do not presently include geothermal operations. No new source performance standards (NSPS) have been established for geothermal exploration or development up to this time. If geothermal NSPS are promulgated, it would affect all future geothermal development as well as existing operations.

Fish and Wildlife Coordination Act (Public Law 85-624). Requires baseline studies of the wildlife in areas to be leased, and the establishment of measures to mitigate harm prior to leasing. These requirements are met through the NEPA and California CEQA processes.

Safe Drinking Water Act (Public Law 93-523 as amended by Public Law 95-190). This act establishes the framework for promulgation of regulations to insure that the sources of drinking water are safe for use by the public. It includes provisions for regulation of injection of substances into underground aquifers which constitute the sole or principal sources of supply for communities.

> 40 CFR 146 - gives the state primary enforcement authority over underground injection.
>
> Regulations are currently being proposed under 40 CFR, Parts 122, 123, and 124 which will consolidate the procedural requirements for the EPA's major permit programs.

Noise Control Act of 1972 (Public Law 92-574 as amended by Public Law 94-301). This act vested primary control of noise with state and local government, but retained Federal regulatory authority over the production of four categories of low noise level products; construction, transportation equipment, motors or engines, and electrical or electronic equipment. Until EPA promulgates regulations on a product, the states are free to set their own regulations, When EPA does issue regulations, state standards must meet Federal regulations. This Noise Control Act, along with the requirements of the Federal geothermal lease, provides noise control for geothermal operations.

Endangered Species Act of 1973 (Public Law 93-205 as amended by Public Law 94-32 and 94-539). This act has the purpose of providing a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, and of providing a program for the conservation of such endangered or threatened species. Section seven of this act requires all Federal departments and agencies to avoid actions authorized, funded, or carried out by them from destroying or adversely modifying critical habitats.

Soil and Water Resources Convervation Act of 1977 (Public Law 95-192). This act establishes the policy that Federal programs shall be responsive to the long term needs of the nation and that conservation of land and water resources is a long term requirement. It provides for the establishment of a

Federal water and soil conservation program.

Toxic Substances Control Act (Public Law 94-469). This act establishes the authority to regulate chemical substances which may present an unreasonable risk of injury to health or the environment. This act, together with the requirements of the Federal geothermal lease, provides controls for toxic substances.

Executive Order 11514 - "Protection and Enhancement of Environmental Quality" March 5, 1970. To further the purpose and policy of NEPA of 1969, the Federal government shall provide leadership in protecting and enhancing the quality of the nation's environment to sustain and enrich human life. This order designates responsibility to Federal agencies to develop procedures to insure timely public information and develop programs to monitor and evaluate 1) pollution control, and 2) enhancement of environmental quality.

Executive Order 11593 - "Protection and Enhancement of Cultural Resources" May 13, 1971. This order directs the Federal government (primarily the Department of the Interior), to provide leadership in preserving, restoring, and maintaining the historical and cultural environment of the nation. Agencies must list in the National Register of Historic Places, all sites or nominations as of July 1, 1973, and provide documentation before any destruction can take place.

Executive Order 11870 - "Environmental Safeguards on Activities for Animal Damage Control on Federal lands". This order directs that it is the Federal policy to manage all public lands to protect all animal resources thereon in the manner most consistent with the public trust in which such lands are held.

Executive Order 6206 (Signed 16 July 1933). This order withdraws a significant amount of land in the area proposed for leasing for the purposes of protection of the water supply of the City of Los Angeles. According to the language of the order, the withdrawal is temporary in aid of proposed legislation. However, there is no record that said legislation was ever passed by the Congress. The land is withdrawn "from settlement, location, sale or entry....". The current legal status of this withdrawal can pose a serious contraint on the development of the Coso Geothermal Resource. According to the Withdrawal Act of June 25, 1910, (sometimes referred to as the Picket Act), the President may, at any time at his discretion, temporarily withdraw from settlement, location, sale, or entry any of the public lands of the U.S. ".... and reserve the same for the public purpose specified in the orders of withdrawals, and such withdrawals shall remain in force until revoked by him or by an Act of Congress." Public Law 94-579, see above, on the other hand, specifies that withdrawals may not be for a duration of greater than 20 years.

Executive Order 12088 (Signed October 13, 1978). This order re-emphasizes that Federal agencies obey "most pollution abatement regulations" and adds that they also comply with state, interstate, and local procedural regulations "just as any private industry must do."

Tripartite Memo of Understanding. This MOU is a joint agreement between the USGS, BLM, USF&WS, establishing Cooperative Procedures in the Geothermal Program, signed 1976. The W.O. 105 addendum to the MOU specifically addresses protection of Cultural Resources from surface disturbing activities related to the Federal Geothermal Lease operations. The W.O. 105 addendum to the MOU and proposed NWC constraints package can be found in Appendix C.

A.3 State and Local Regulatory Constraints

The regulatory agencies throughout California concerned with the development of geothermal energy at Coso, have been contacted by the California State Energy Commission Geothermal Advisory Committee. The Committee subsequently developed a document identifying the concerns and constraints of these regulatory agencies. This document is available through the BLM Bakersfield Office, as well as the California State Energy Commission. Inyo County has a Geothermal Element included in the County's General Plan which gives guidelines for the exploration, development, and eventual shutdown of geothermal operations. This document is available through the Inyo Planning Commission.

APPENDIX B

GEOTHERMAL DEVELOPMENT MODEL

B.1 INTRODUCTION

The contents of this report have been prepared to provide a technical basis for the Geothermal Development Model upon which Chapter 1, Proposed Action the Coso Geothermal Leasing Environmental Statement has been prepared. The geological portion of the report has been prepared by Harding-Lawson Associates, in conjunction with Mr. James B. Koenig (GeothermEx, Inc.) and represents the best judgments of various experts in the field of geothermal reservoir characteristics. The section describing the above ground facilities which will be constructed was prepared by the Advanced Engineering Department of the Energy Systems Group of Rockwell International under the direction of Mr. Bruno Katz.

It must be noted that much of the material presented is based on limited data and thus must be considered as the best available estimates at this time. Improvements in technology, further geologic and hydrologic studies, and changes in the economy can all invalidate many of the conclusions reached.

B.2 RESERVOIR DEVELOPMENT MODEL

B.2.1 Field Parameters

B.2.1.1 Geothermal Reservoir Fluid

Plutonic and metamorphic basement is believed to be present at depths of a few tens to a few hundred feet throughout the central Coso Range. Therefore, all deep geothermal tests will terminate in basement. Fractured granitic and metamorphic rock is believed to serve as the geothermal reservoir at Coso Hot Springs. Fractures include ancient joints and cleavage planes, more youthful faults, and shatter zones thought to be present at major fault intersections.

Dominant fracture trends, as discussed above, are NNE-SSW NNW-SSE, ENE-WSW, and WNW-ESE, with older but probably significant fracturing along northwest trends. Intersection of faults of the first two trends appears to control the thermal discharges at Coso Hot Springs, the Nicol Prospect and the Devil's Kitchen.

Porosity of the Coso Geothermal Reservoir is not presently known. The recently attempted flow test of CGEH-1 (Goronson and Schroeder, 1978) was not informative because of plugging of the formation with drilling mud and lost ciruclation materials during drilling. Hence, porosity in the basement must be estimated from the physical properties of the rock, comparisons with rocks of similar structure and lithology, and the following assumptions:

A. The rock matrix has no primary porosity.

B. All flow and storage is in fractures.

C. Porosity will vary widely with the degree and openness of fractures.

Acknowledging the inadequacy of currently available data, porosity or permeability estimates for the Coso Reservoir must be considered speculative. An average porosity value of 5% is considered not excessive, with a minimum value of 3% for less-fractured regions. Probably there will be zones of much higher porosity adjacent to major faults or fault intersections, and zones of even lower porosity associated with certain lithologies. Permeability is estimated on this basis to range from a few millidarcies in less fractured zones, to several hundred millidarcies at major fault intersections. Drilling logs for CGEH-1 indicate sections of hole that have yielded considerable amounts of water and sections that have accepted copious quantities of drilling mud. Both of these indicate zones of high porosity and permeability.

Locally, porosity and permeability may be affected by solution and deposition activity, such that certain fractures may be sealed by silica, carbonate minerals, or clays, and other fractures may be enlarged by the solution of silica. All fractures may be enhanced by tectonism; indeed without continued tectonism, fractures into the reservoir might seal permanently.

Fluid within the reservoir is believed to be entirely water, with only a shallow cap of steam located above the water system. This steam cap has low pressure, limited quantity, and localized existence along active fractures, such as at Coso Hot Springs, where it is seen as fumaroles. No commercial production of this steam cap is foreseen.

The deep fluid is strongly chlorided, with TDS of perhaps 6,000 to 6,500 mg/l. Estimates of concentration of specific species are as follows: Cl, 2,700 mg/l; Na, 1,700 mg/l; Silicon Dioxide, 700 mg/l; B, 60 mg/l. Non-condensible gases are estimated to comprise one-half percent by volume, mostly carbon dioxide, but with small concentrations of hydrogen sulfide, and probably other species. Fluids discharging to existing wells or to the surface probably are influenced both by mixing with shallow, cool ground-water and by separation of steam by boiling. The former effect dilutes the reservoir fluid; the latter concentrates the non-volatiles. In a recent investigation (Kubin, 1978) the composition of non-condensible gases emanating from Devil's Kitchen, Nicol Mercury Prospect, and Coso Hot Springs was determined . The values reported are: Carbon dioxide, 97.9%; hydrogen sulfide 1.8% with methane and hydrogen making up the remainder. It should be noted that these samples are not representative of the geothermal fluid contained in the reservoir.

Maximum temperature within the reservoir has been estimated (Fournier et.al., 1978) as 240°C (465°F), possibly as high as 275°C (525°F) locally or in deeper sections. Maximum observed temperature is about 195°C (380°F) in the 4,845 foot deep CGEH #1, in a zone about 2,700 feet deep. Isotherms clearly were controlled by fracture distribution in that well, such that vertical relief on any isotherm may reach several thousand feet, depending upon presence and orientation of open fractures. Becasue of this, it is difficult to estimate the depth to the 240°C isotherm, or even to the 200°C isotherm at the Coso Geothermal field.

In the presence of major fractures, and especially fracture intersections, 200°C may be encountered at less than 1 km (3,300 feet). Estimates of isotherm depths outward from such fractures are based on implication and extrapolation from linearity of gradients, depth of water table, concentricity of heat flow values, shallowness of microseisms and location within or outside of the 10 HFU zone. In general, it is believed that 200°C will be reached, in most cases, by 2 km (6,500 feet) within the 10 HFU zone, and possibly at shallower depths locally. Within the 5 HFU zone, depth to the 200°C isotherm may not exceed 3 km in most cases. In the presence of major fractures, depths may be appreciably less.

Enthalpy of the thermal fluid has been estimated (Fournier et.al., 1978) to be 235 to 290 cal/gm (420 to 525 BTU/lb). Pressures at depth are believed to be approximately hydrostactic.

B.2.1.2 Extent of Resource

The Coso Geothermal Resource has been divided into four zones which are described in Chapter 1 of the ES. Each zone has a different power-production potential, ranging from the highest in zone 1 to the lowest in zone 4. Zones were selected on the presence or abundance of criteria presumed cumulatively to be indicators of high temperature and porosity at depth: heat flow; intensity and distribution of faults and other fractures, especially those cutting quaternary deposits; hydrothermal alteration, silicifation, or mineralization; age of silici volcanism; age of basaltic volcanism; temperatures in drilled holes; fumaroles and warm ground; microseismicity; and aeromagnetic and electrical resistivity lows. Of these, only microseismicity, faulting, fumarole activity and hydrothermal alteration, and possibly resistivity lows, are presumed to be related to porosity and permeability. The entire suite of indicators is presumed to indicate high temperatures.

Zone boundaries in all cases follow section lines. This is arbitrary and most assuredly is not the case in nature. However, because leases will be granted by section, this appears to be the most realistic means of setting lease-unit boundaries.

Percentages given in the following prargrahs are based upon experience elsewhere in plutonic-metamorphic terrain, such as at Raft River, Idaho, and Roosevelt Hot Springs, Utah. These numbers are admittedly speculative. Reviewers at the USGS have declared them to be optimistically high, whereas reviewers at the U.S. Naval Weapons Center consider them to be unrealistically low.

Zone 1 consists of an area of about 6 square miles, centered on the fumaroles of Coso Hot Springs, the Nicol Mercury Prospect, and Devil's Kitchen. This area lies entirely within the 10 HFU contour, and is characterized also by abundant shallow microearthquakes, an aeromagnetic and electrical resistivity low, prominent faults trending NNE-SSW, northwest-southeast and northeast-southwest, and abundant hydrothermal alteration. The area also includes parts of the youngest age-dated rhyolite dome, Sugarloaf Mountain, at 44,000 $\pm$ 22,000 years (Bacon, 1978). Within it are the two highest temperatures obtained in wells: 287°F (136°C) at 375 feet, at Coso Hot Springs; and nearly 195°C (380°F) at about 2,700 feet in CGEH #1.

This zone is considered the most likely to become commercially productive of geothermal energy; chances of finding 200°C temperatures by 2 km (6,500 feet) are rated herein at over 90% (1).

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(1) Estimates made by the USGS in a review of this document are given for comparison with those made by the authors.

Chances of	This USGS	Report
T 200°C at 2 km, Zone 1	70%	90%
Wells being productive by 2 km, Zone 1	40%	67%
T 200°C at 2.5 km, Zone 2	45%	65%
Wells Being Productive by 2.5 km, Zone 2	20%	50%
T 200°C at 3 km, zone 3	10%	35%
Wells being Productive by 3 km, Zone 3	5%	33%
T 200°C at 3km, Zone 4	5%	1/t20%
Wells Being Productive by 3 km, Zone 4	2%	1/t 12.5%

Although USGS values are lower than those of this report, there is general agreement in downward trend of values from zones 1 to 4. Degree of disagreement is least in Zone 1 becoming progressively greater in Zones 2,3, and 4.

It is estimated further that the highest field permeabilities will be encountered along major fault zones within this zone and at their intersections, as discussed above. Likelihood of individual acreage being productive of geothermal fluid is rated at two chances in three (67%). Flow rate probably will be the determining factor for productivity. On Figure B.2-1 it is described as zone 1, and that terminology is used hereafter. Outward from this, is a group of nine sections within which the chance of finding 200°C temperatures by 2.0 to 2.5 km (6,500 to 8,200 feet) is rated at 65%. Permeability is considered to be lower than in zone 1, but at least equal to the regional average. In outline, it corresponds closely to the 10 HFU boundary; all thermal manifestations are within its outer boundaries; it includes several of the rhyolitic domes. Acreage within it is considered to have one chance in two (50%) of becoming productive. It is referred to as zone 2.

Outward from zone 2, are 31 sections (zone 3) rated as perhaps 35% sure of encountering temperatures of 200°C by 2.5 to 3.0 km (8,200 to 10,000 feet). The 5 HFU contour falls within this zone, as do most of the youthful rhyolite domes and certain of the youngest basalt eruptive centers. In part, it extends west of the Coso Range, onto the floor of Rose Valley in the vicinity of young basalt eruptives and occasional high HFU values. Acreage in zone 3 has one chance in three (33%) of becoming productive, although permeabilities are considered likely to be lower than in the zones 1 and 2.

These three zones together comprise some 46 square miles. It is considered likely that the overwhelming majority of producible geothermal resource will be located within their borders.

However, a fourth zone (Zone 4) is defined, consisting of 30 sections, within which chances are less than one in five (20%) that temperatures of 200°C will be encountered by 3 km (10,000 feet). It includes all residual features of passing geothermal interest, including seismically active zones, moderate heat-flow values, older eruptive centers, and lands lying between higher-rated zones but not included in them. Permeability is suspected to be low in much of the acreage. Acreage in zone 4 is considered to have less than once chance in eight (12.5%) of being commercially productive for electrical generation purposes.

Beyond this zone, no likelihood is ventured that acreage will be productive. Probably even within this zone there will be very little development of geothermal resources.

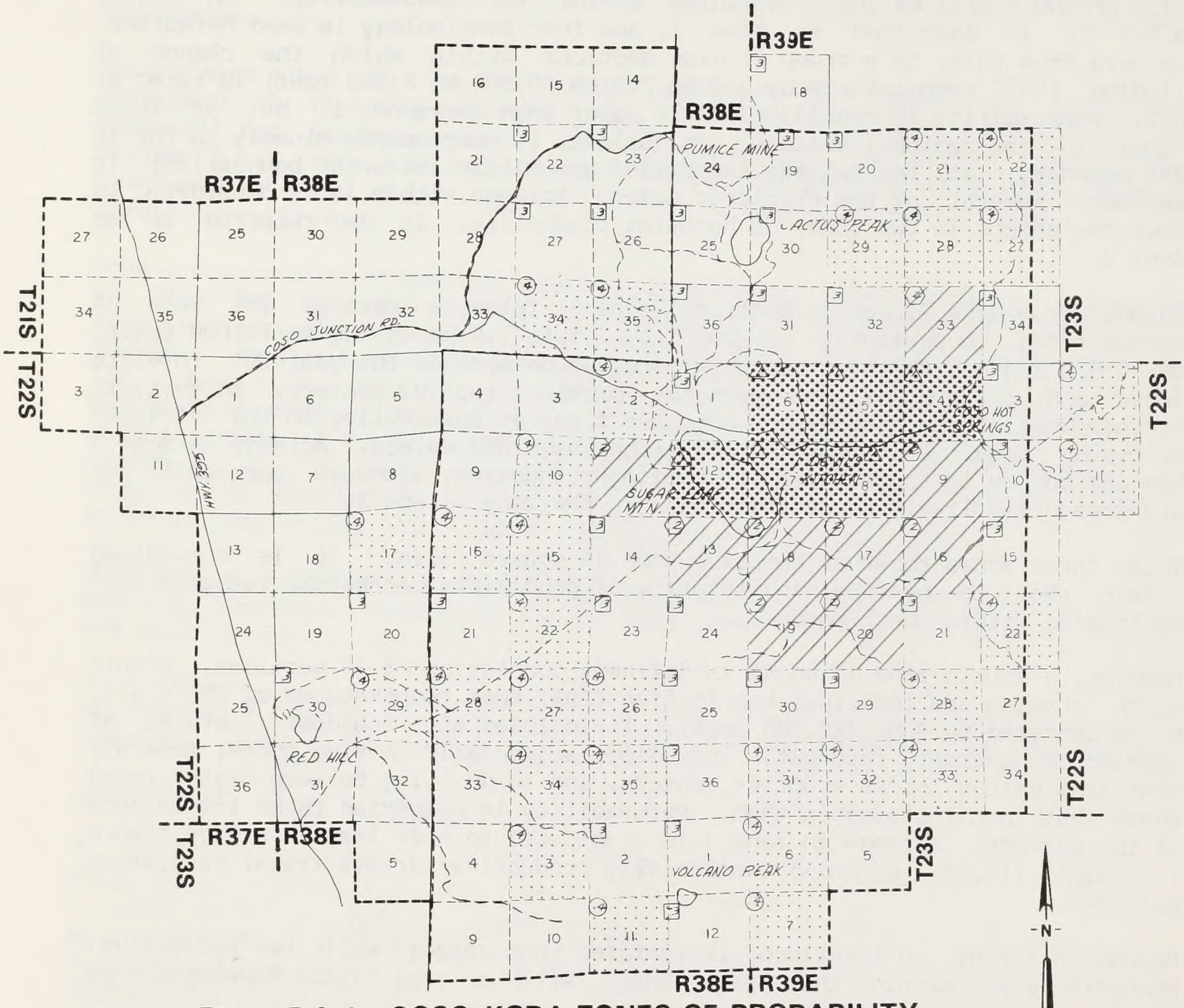

Figure B.2-1 COSO KGRA ZONES OF PROBABILITY

1 High Probability
3 Low Probability
2 Moderate Probability
4 Uncertain
—— NWC Boundary

0 5 Miles

B.2.2 Development Model

B.2.2.1 Well Characteristics

B.2.2.1.1 Depth

Within zone 1, completed well depth is expected to range from less than 1.5 km (5,000 feet) to over 2.5 km (8,200 feet), with shallower wells located so as to intercept major fractures. Median depth in this zone is forecast to be 2 km (6,500 feet).

In zone 2, well depth is expected to be slightly greater on the average, perhaps being 2.3 km (7,500 feet). Along fractures, individual wells may be as shallow as 1.5 km (5,000 feet); however, depths to 3 km (10,000 feet) may be expected, especially where temperatures are found to be marginal but fractures are not easily found.

Zones 3 and 4, and the area beyond these zones, will be characterized by deeper holes, the shallowest (except for holes abandoned prematurely for mechanical reasons) being perhaps 2 km (6,500 feet), and the deepest extending to beyond 3 km (10,000 feet).

In each of these zones, it is likely that certain holes will be abandoned far short of their objective depth for a variety of reasons: money, drilling problems, loss of confidence, regulatory constraints. For this reason, some holes may be abandoned or suspended at depths much shallower than those foreseen above for production wells.

B.2.2.1.2 Productive Capacity

As discussed above, porosity and permeability are likely to vary widely and quantitative estimates of their value are speculative. It is anticipated that the porosity and permeability often will be low, except in the vicinity of major faults and fault intersections. Permeabilities of a few to perhaps a few dozen millidarcies are assigned to most sites outside of zone 1. Within zone 1, permeabilities are expected to be greater: several dozen to several hundred millidarcies, especially along the faults that control the present day fumaroles and other manifestations.

It is difficult to convert permeability to mean yield, even if a permeability thickness coefficient can be derived by estimating the vertical extent of fractured rock encountered per well. Instead, comparisons are drawn with productive geothermal systems elsewhere, especially in regions of apparently constrained permeability.

well-to-well; and field averages sometimes fail to include wells of subcommercial productive capacity. However, for many systems certain generalities can be drawn.

Temperature, enthalpy, fluid state, pressure and mass flow per well fall within the same broad range at Ahuachapan, El Salvador; Momotombo, Nicaragua; Valles, New Mexico; El Tatio, Chile; and Roosevelt Hot Springs, Utah. However, in each of these systems, individual wells exhibit widely variant behavior. In each, non-productive holes are scattered amongst commercial wells. Each field exhibits fracture permeability. In all of these factors, they are similar to the projections made for Coso. Further, Roosevelt, like Coso, is in granitic-metamorphic terrain, associated with youthful rhyolite domes, apparently overlying molten or semi-molten rock at depth, and characterized by high heat flow and temperature gradients.

As a group, these systems yield from less than 100,000 to over 1,000,000 pounds of total fluid per hour per well. Steam flash varies from less than 20% to over 30%, depending upon enthalpy and flow pressure. Flow pressure is likely to be in the range of 100 to 150 psig for an eight inch hole. Conversion to electricity at Ahuachapan is accomplished at about 18 pounds of steam per kw-hr; the other systems discussed herein are not yet in commercial production but probably will have similar conversion rates.

At Roosevelt Hot Springs, there are no long-term production values for stabilized well yield, but only short-term test data. These suggest a wide range of yields. Experience in hot water fields, as well as in dry steam fields, suggests that declines in pressure and mass flow will be experienced during a period of some three to seven years. Eventually the rate of decline will asymptotically approach stability. This may be expected at Roosevelt and at Coso.

For the purposes of projecting the development at Coso, deliberately conservative figures have been selected: initial total flow of about 200,000 pounds per hour per well, decreasing to 150,000 pounds per hour with time. For zone 1, this may be 250,000 pounds, declining to 200,000. Elsewhere, stabilized values may be slightly lower than 150,000 pounds. The conservative flash rate of 20% has been adopted, thereby yielding stabilized steam flow of 28,000 to 40,000 pounds per hour. Of course, these values will be determined ultimately by the energy-conversion system used; dual-flash may yield significantly higher quantities of steam from the same total mass flow. Similarly, the conversion rate of 18 pounds of steam per kw-hr is arbitrary.

Binary or other total mass conversion systems also may yield more energy per pound of fluid than in the flash steam process. These values, however, yield approximately 2.25 MW per well within zone 1, and approximately 1.67 MW per well outside of it. It must be emphasized that individual wells will vary widely from this average figure. It should also be noted that these values are comparable to those derived by testing at Momotombo, Nicaragua, and only slightly lower than tested at El Tatio, Chile. They are, however, lower than the 3 to 6 MW per well tested at Roosevelt, Ahuachapan, and Valles. Only at

Ahuachapan are production stabilized values available; these are about 5 MW per well, at a higher flash percentage (approximately 25%) and a slightly higher total mass flow per well than used herein for estimation of the Coso capacity.

B.2.2.1.3 Fluid characteristics

As discussed earlier, a chloride-rich hot water is expected at Coso, having TDS of 6,000 to 6,500 mg/l, at a temperature of about 240°C (465°F) (Fournier et al, 1978). In deeper sections of the field, temperatures to 275°C (525°F) may be encountered. Enthalpy for this fluid is projected to be 235 to 290 cal/gm (420 to 525 BTU/pound). Concentration of selected species is projected as follows:

Species	mg/l
Chlorides	2,700
Sodium	1,700
Silica	700
Boron	60

Non-condensible gases may comprise 0.75% to 1%, by weight of the steam component. Of these gases, 99% by weight, will be carbon dioxide, less than 1% hydrogen sulfide, and the remainder a mixture of methane, nitrogen, hydrogen, and trace gases. Shut-in pressure is expected to be approximately hydrostatic. Flow pressures will be dependent upon well diameter and choke; this in turn may depend upon, or influence, the decision taken regarding the mode of power generation.

Fluid pH may be mildly acid to mildly alkaline. However, no extreme of either acidity or alkalinity is foreseen. Scaling of silica may be expected if not inhibited. Similarly, some corrosivity may be anticipated.

Nothing is known of the concentration of such toxic species as arsenic, mercury, lead, or cadmium. However, several parts per million does not seem excessive for the combined value of these and related heavy metals. Fluorine may be present at about 10 mg/l.

During drilling, hydrogen sulfide gas emission may become a problem, especially if pyritiferous rock is encountered. Similarly, the shallow, low-pressure steam cap anticipated to be present locally along major fractures above the hot water system may be rich in hydrogen sulfide, and may be both toxic and corrosive.

B.2.2.2 Field Characteristics

B.2.2.2.1 Total Area and Total Yield

As described earlier, an area of 6 square miles (zone 1) is anticipated to be productive across two-thirds of its acreage, at a stabilized rate of about 2.25 MW per well. Out from zone 1, productivity per well is expected to be lower, perhaps being 1.67 MW on average for zones 2 and 3 and beyond.

Within zone 1, approximately 1,600 acres of the total 3,840 acres is U.S. Navy fee land, excluded from this study. This includes the most attractive acreage spanning the fumarole zones of Coso Hot Springs, the Nicol Mercury Prospect, and the Devil's Kitchen. This Navy acreage is considered to be at least as productive as the remaining 2,240 acres of zone 1. Further, one section, consisting of approximately 520 acres of Navy fee land and 120 acres of non-fee land, is within an area listed in the National Register. Exploration and development on this section will be restricted possibly to the point that all development drilling will have to be done from off the site by directional methods.

On a 40-acre well spacing (see below), approximately 96 well sites could be developed on zone 1. Of these, it is estimated (see above) that 64 will be productive, including both the National Register land and Navy fee land with the total. At 2.25 MW per well, 144 MW capacity is calculated for zone 1. However, because of the anticipated higher permeability of lands along the major fractures represented by the present-day fumaroles, the Navy fee land, although only 42% of total, is expected to yield 50% of the 144 MW. Therefore, some 72 MW (1) of electricity is anticipated from the Bureau of Land Management lands within zone 1.

Of zone 2, just over one-half section (360 acres approximately) is Navy fee land. No restrictions on access or surface occupancy are noted for the remaining acreage, which total about 5,400 acres.

An assumption of 50% productivity has been made (see above) along with an average well capacity of about 1.67 MW per well. From these figures, again at a well spacing of one per 40 acres, a capacity of about 120 MW is derived, for some 72 productive well sites. This appears to be realistic considering uncertainties as to location and dimensions of a magmatic heat source.

Zone 3 consists of 31 sections (approximately 19,840 acres), of which about one section is Navy fee land,and approximately 80 acres are listed in the National Register. Additionally, one section is withdrawn from surface occupancy, thereby requiring directional drilling from off the parcel.

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(1) Estimates of power-generation potential derived herein are considered to be "optimistic" by reviewers of the U.S. Geological Survey.

An assumption of approximately 33% productivty has been made for lands in zone 3, coupled with yield of 1.67 MW per well, and a well spacing of one per 40 acres. For the entire unit, this yields a capacity of 273 MW, almost entirely on BLM lands. This number may be too high, considering the uncertainties of heat source, location, and dimension, and the relatively low heat flow values obtained to date in portions of zone 3. Even if it were halved, however, it would appear of approximately equal magnitude to zones 1 and 2 in resource capacity.

No estimate of productivity is made for zone 4 or for lands still beyond that zone, although it is recognized that some resource may be encountered while exploring those areas.

Based on the foregoing model and assumptions, zones 1, 2, and 3 will yield from 400 to perhaps over 536 MW of geothermal electricity, of which some 72 to 85 MW will be on Navy fee land. Of this total, the first 144 MW is considered to be probable to highly probable, and is likely to be developed as fully as land use constraints allow. The second 120 MW (zone 2) is considered possible to probable, but may be developed more slowly than the zone 1 resource, because of anticipated lower capacity per well, leading to higher development costs per megawatt. The 137 to 273 MW calculated for zone 3 is possible, but not probable, and may never be developed in full, again because of the expected high cost per megawatt to explore and develop.

B.2.2.2.2 Well Spacing and Well Life

Relatively little is known about productive life for either wells or fields in hot-water systems. It is a truism, however, that field life will exceed well life, as individual wells are abandoned because of depletion of resource or for mechanical or chemical reasons. At The Geysers dry steam field, well life is approximately ten years, based on abundant data for the past decade, and on sparse data for nearly two decades. Field life there is expected to be at least 30 years, but without published documentation to support this assumption.

The longest lived hot water field to date is Wairakei, New Zealand, where production has gone on for nearly two decades. There, declines in pressure and mass flow have restricted generation to levels below those originally planned. At Cerro Prieto, Mexico, production has proceeded for about five years, reportedly with no adverse effects on the reservoir. However, problems in completion of early wells led to complete reworking of production wells prior to initiation of production.

It can be assumed with confidence that early wells drilled into any system will be completed unsatisfactorily, requiring either recompletion or abandonment after a short production life. Subsequent wells may profit from this initial experience, so that the percentage of long-lived production wells will increase with experience. It probably is not too bad an assumption that to maintain a single production well, three drillings will be required, some years apart in time. This is in addition to dry holes and other failures.

Well spacing in hot-water systems usually is closer than in dry steam fields, because the total fluid in storage is greater in hot-water systems, although yield per well may not be significantly greater. At The Geysers, a 40 acre spacing pattern has been adopted, with allowances for later make up drilling at a 20-acre spacing, or closer, if desirable. At Cerro Prieto, an initial spacing of approximately one per five acres has been replaced by approximately one per 12 acres. Spacing at Roosevelt Hot Springs is a subject of study, with one per 20 acres possible. At Ahuachapan, one per approximately 15 acres has been adopted.

Because of the lower anticipated permeability at Coso, a spacing of one per 40 acres is suggested herein. However, that can only be determined after production wells have been completed and extensive reservoir tests have been run.

Further, in a fractured reservoir, communication between wells is likely to follow linear paths corresponding to fault traces. In such a system, development might be irregular, with interference occurring between distant wells on the same fault system and not between other, closer wells which are not connected by faulting.

B.2.2.2.3 Field Life

As mentioned above, assumptions of 30-year field life are common, usually reflecting the desire of the electric utility to amortize its plant and other facilities over that period of time. However, only in one field, Larderello, Italy, has production gone on for such a length of time.

At Larderello, production before World War II reached an installed capacity of 130 MW by 1943. This was destroyed late in WW II. After the war, production rose to over 250 MW by 1950 and to the present day total of over 400 MW in the early 1970's. Therefore, even at Larderello, output has been sustained at a high level for only one-quarter century. Interference has been reported between wells, local pools have had to be abandoned or have had deeper wells drilled into them, and replacement wells have been needed frequently. However, the system does not show signs of exhaustion. Therefore, a 30 year productive life may not be unreasonable for a dry steam field.

At The Geysers, productive capacity is still being added. Some indications of depletion have been noted in all sections of the field (Lipman et al, 1977; Isherwood, 1977). However, after over a decade of strong production no indication of exhaustion has been observed.

Conversely, it might be possible that the life of a carefully managed field may greatly exceed 30 years. This may be an argument for unitization of leases.

B.2.2.2.4 Fluid Consumptive Demand

Consumptive demand for water may become a critical factor in a water deficient area, such as Coso. However, there are many strategies that can be used to minimize water consumption, once the critical limitations are known. This section explores the relationship between precipitation, recharge, extraction of geothermal resources, and reinjection.

As discussed earlier, average precipitation across the ES Study area is only 5 inches annually. Recharge from direct precipitation in only 390 acre-feet per year for the sub-basin of greatest interest. Deep recharge from the Sierra Nevada is approximately 2,800 acre-feet, or 260 acre-feet per linear mile of Sierran front (Spane, 1978). Much or all of this deep recharge passes through to the adjoining sub-basin on the east or southeast (Spane, 1978). Previously, it was estimated that average stabilized flow per well might be 150,000 pounds of fluids per hour, possibly reaching 200,000 in zone 1. Of this total, some 20% would be flashed to steam for power generation. The remaining fluid would then become a disposal problem. If no re-injection is practiced, consumptive demand per 2.25 MW well (200,000 pounds per hour) would be 515 acre-feet per year; for a 1.67 MW well (150,000 pounds per hour), consumption would be 386 acre-feet annually. For a 50 MW plant, consumptive demand would be on the order of 11,500 acre-feet per year. This easily exceeds all forms of natural recharge. If there is hydraulic communication between deep ground water and the hydrothermal reservoir, the deep water table will be lowered at a rapid rate.

Reinjection of the liquid residue of flash geothermal operations is practiced successfully at Ahuachapan, El Salvador, and is planned for future geothermal production at Roosevelt Hot Springs and Heber, California. Quite probably, it would be stipulated that such reinjection be carried out at Coso. This would reduce consumptive demand to only the portion of steam condensed and evaporated in cooling towers.

If all flash steam were evaporated to the atmosphere, annual consumption would be approximately 20% of 11,500 acre-feet per 50 MW plant, or about 2,300 acre-feet per year. This figure exceeds direct recharge from rainfall onto zone 1 by a factor of at least 6. Only if all deep underflow from the Sierra Nevada front were captured in the geothermal wells (or served as make-up at depth for fluid captured into the deep wells) would a 50 MW plant result in no consumptive demand. This is unlikely, as zone 1 intercepts only 2 linear miles of Sierran front. Even allowing for induced development of a flow pattern toward these deep wells, it appears unlikely that all of this deep recharge would go to replace geothermal fluid consumed by these wells.

At 3 and 5% porosity (see above for source of these numbers), a cubic mile of reservoir would contain 100,000 and 170,000 acre-feet of water, respectively (numbers are rounded off because of thermal effect on volume at depth). Per foot of drawdown, there would be some 2.3 and 3.9 hectare-meters (19 and 32 acre-feet) of fluid per square mile, respectively. Under the best of conditions (deep recharge equals consumptive demand for flash steam), there would be no drawdown in the permanent water table. Under assumptions of net consumptive demand of about 210 ha-m (1700 acre-feet) per year for the first 50 MW plant, the permanent water table might decline from 27 to 45 feet annually. This would be 9.4 to 16.1 meters (31 to 53 ft) if the 37 ha-m (300 acre-feet) of cooling tower make-up is included. This calculation ignores many important considerations of directional flow at depth and assumes hydraulic connection between shallow and deep aquifers. It may be challenged successfully on these and other bases. However, lacking detailed hydrologic data, it offers an order of magnitude calculation of the annual effect of consumption of flash steam by evaporation.

CALCULATIONS OF DRAWDOWN

Fluid in Storage

Porosity (%)	ha-m/ cu km	Fluid in Storage Cubic Miles	Drawdown per sq km	per sq mi
5	5031	170,000	5	32
3	2959	100,000	3	19

CONSUMPTIVE DEMAND

First 50 MW Plant (Zone 1)

Assumptions: Reinject all post-flash fluids. Evaporate all flash steam.

Per 50 MW, consumption is approximately 284 ha-m (2,300 acre-feet) per year.

Annual Recharge:

	ha-m	acre-ft
Direct Sub-basin precipitation	48	390
Deep Sierra Nevada Underflow	375	2,800
	393	3,190
Per min N-S, direct precipitation	4.9	40
Per mile N-S, Sierran underflow	32	260
	37	300
Zone 1 intercepts 2 linear miles N-S		
Therefore, total annual recharge	74	600

Assumption: There is no deviation from linearity in net flow resulting from flowing geothermal wells.

Net Concumptive Demand:

	ha-m	acre-ft
Flash Steam	284	2,300
Recharge	-74	-600
	210	1700
Cooling Make Up	37	300
	247	2,000

50 MW represents approximately 2 sections of land in Zone 1.

(2.25 MW/well) (16 productive wells/section) (0.67 success factor)

Therefore, 210 ha-m (1,700 acre-ft) net consumption come from 5.2 sq km (2 sq mi); at 3 to 5 ha-m per m per sq km (19 to 32 acre-feet per foot) drawdown of consumption at 3 to 5% porosity, the NET ANNUAL DRAWDOWN is 8.2 to 13.7 m (27 to 45 feet). If we include consumption of cooling make up the NET ANNUAL DRAWDOWN is 9.4 to 16.1 m (31 to 53 ft).

It is increasingly difficult to extend these calculations to the second or subsequent geothermal power plants at Coso, because of the large number of unprovable assumptions that must be made. However, for a total of three plants within zones 1 and 2 having 150 MW capacity, net consumptive demand might range from nearly 3,000 acre-feet per year to about 6,500. This range of values represents uncertainties regarding deviation of deep flows towards the well field, number of square miles involved in production, and number of line miles north-south involved in development, as well as percent porosity and yield per well.

Such consumptive demand might result in net annual lowering of the water table by up to 50 feet across an area of some six to seven square miles.

What appears certain is that at some early stage in development of the geothermal resources at Coso, declines in the permanent water table will occur. If these are not controlled, other effects may be generated over the life of the field. These effects include:

A. Decrease in yield of power per well

B. Increase in enthalpy of fluid, and thus in percent of steam flash

C. Subsidence of the ground surface

To minimize these effects, it might be stipulated that either no evaporative loss of steam will be allowed; or that losses will be made up by replacement fluid from some other source. It remains unclear what this replacement source would be. Alternatively, unitization of production, with careful hydrologic monitoring, might allow for a steady annual drawdown in the permanent water table without harmful results to the geothermal field.

More than any other factor, detailed hydrologic studies will be required as an accompaniment to drilling of production wells.

B.2.2.3 Development Phases

B.2.2.3.1 Surface Exploration and Shallow Drilling

Within zone 1, drilling of deep geothermal test wells probably will occur without a significant interval of intensive surface exploration. There may be a brief stage of drilling of deep temperature-gradient holes (to 1,500 or 2,000 feet) prior to or concurrent with deep exploratory drilling, but this is unlikely, as there will be significant geophysical, geological or geochemical exploration at the surface.

In zone 2, there is likely to be drilling of gradient holes to depths of 300 feet to 2,000 feet, possibly accompanied by seismic and geoelectrical surveys, prior to deep exploratory drilling. However, drilling of deep geothermal tests might proceed along with the drilling of deep gradient holes.

The principal factors determining the timing and location of deep geothermal tests will be lease stipulations and permitting time. That is, if deep exploratory drilling can begin at once on federal leases, there is likely to be a shorter period of surface exploration, with perhaps the drilling of deep geothermal test wells at once. It is unlikely that zone 2 will be drilled prior to zone 1 unless land-use constraints so dictate.

Zones 3 and 4 and beyond are likely to undergo detailed exploration prior to drilling of deep exploratory wells. This work probably will include seismic, electrical and heat-flow surveys, and possibly will include gradient holes to as deep as 2,000 feet. It is unlikely that deep exploratory drilling in these zones will precede it in zones 1 and 2, unless the latter are constrained by land-use stipulations.

Zone 4 and beyond may be explored contemporaneously with zone 3, through to the point of deep geothermal drilling. There is the likelihood that surface exploration and the drilling of shallow gradient holes will be as intensive in zone 4 as in zone 3, but there are likely to be fewer deep geothermal tests.

As discussed above, hole depth is likely to be greater in zones 3 and 4 than in zone 2 and especially zone 1. However, because of the number of holes, total drilled footage probably will be greatest in zones 1 and 2.

Because of their size and remoteness, parts of zone 4 and beyond may receive nothing more detailed than walk-through surface exploration (geologic mapping, gravimetry, geochemical sampling) with no permanent surface disturbances. Within zone 3, exploration probably will include construction of drill sites, and perhaps shallow excavations for seismic surveys, and the construction of roads for drill rigs and other vehicles.

Zones 1 and 2 can expect continued surface disturbance, especially in the form of drill sites and access roads. Those areas in which no surface occupancy is allowed would be possible to explore remotely from off-site, up to and perhaps including drilling of directional holes beneath the areas. This would, of course, be conditional upon resolution of questions of Indian tribal rights on Coso Hot Springs.

B.2.2.3.2 Primary Development Zone

It is believed that zone 1 will be the focus of initial exploration and development, both on Bureau of Land Management (BLM) land and on Navy fee lands, unless some exterior constraints are applied to prevent this. Lacking such constraints, it is likely that the first well(s) will be drilled on Navy fee land. Results from this drilling will condition the response of private developers elsewhere on the Coso Geothermal area.

It is assumed here that the first discovery will be made within the Navy lands in the vicinity of Devil`s Kitchen (Coso Hot Springs is a National Register site, and may be unapproachable directly). This will lead to additional drilling of confirmatory wells in that region. This will have the effect of increasing attention to all lands in the vicinity, and probably increasing the values bid in subsequent lease sales. Therefore, lands within zones 1 and 2 should be offered first, as an encouragement to development. Lands of zones 1 and 2 probably will be explored simultaneously, unless parcels are not offered simultaneously.

It is the objective of the Navy to have the first geothermal power plant in operation on its fee lands by approximately mid 1985 (Dr. C.F. Austin, private communication, October 10, 1978). It is extremely unlikely that a power plant can become operational on other lands at Coso as soon as this. However, whether on Navy or public land, it is believed herein that the first plant will be constructed to utilize fluids produced from zone 1. The Navy plan is for an approximately 10 MW plant initially, to supply base needs at China Lake. This could be supplied by five production wells, as discussed above; plus at least one disposal well and one production well in reserve.

To produce some 50 MW of electricity elsewhere in zone 1 would require some 23 production wells, plus perhaps two reserve production wells and some six to eight injection wells, all to be located on approximately 2 square miles in the area. Reinjection is anticipated to require one reinjection well per three to four production wells. This is comparable with experience at Ahuachapan, El Salvador and with plans for Heber, California.

Elsewhere there is a discussion of drilling success ratios anticipated for various portions of the Coso Geothermal field, and the total number of holes to be drilled per year and per decade. Here it is sufficient to state that for a plant to be available for operation within six years of awarding geothermal leases, there will have to be some ten holes per year drilled in zone 1, exclusive of Navy fee land. This appears beyond the capacity of a single drilling rig operating full time, and probably will require two rigs in continous operation. On Navy land, some 10 to 12 holes will be required for the first 10 MW plant, allowing for dry holes, reserve production wells and reinjection, or perhaps two per year through 1985.

If success is attained in zone 1, the level of exploratory effort will increase greatly elsewhere in the region. If success is lacking, interest will die off, with the likelihood that bids for KGRA units will drop and perhaps cease. If there are ambiguous results, exploration will be spasmodic and without continuity. Therefore, to ensure that development occurs throughout the KGRA, every effort should be made to encourage bidders in the first sale by offering lands in zones 1 and 2, and to encourage prompt and sound exploration on these parcels by minimizing restrictive stipulations.

A second 50 MW power plant in zone 1 may not occur until there has been exploratory drilling elsewhere in zone 2 and possibly in zone 3, perhaps with attendant discoveries.

B.2.2.3.3 Subsequent Development Zones

It is considered likely that zone 2 will be the site of the second major discovery at Coso, with construction of a power plant resulting therefrom. This may post-date construction of both the Navy`s 10 MW plant and a 50 MW plant on public land in zone 1. It probably will precede a decision to construct a second 50 MW plant in zone 1 on either Navy or public land.

Zone 2 is considered to be not as productive as zone 1. For this reason, wells may be deeper on an average, and yield per well may be lower (1.67 MW versus 2.25 MW). Additionally, there may be the need to do significant surface exploration and drilling of temperature gradient holes prior to drilling the first deep exploration test. All of these factors will add significantly to the cost of producing geothermal electricity from zone 2. The net effect of this could be to delay any decision to construct a geothermal power plant in zone 2 until:

A. The price of geothermal energy has increased greatly,

B. Operational constraints are reduced, and/or

C. The demand for new energy sources has produced significant tax and other government benefits to the operators.

This may result in delays to construct a power plant until the end of the next decade or later. Price or other concessions may permit construction to begin several years earlier. This becomes especially true for still subsequent plants, wherein local demand will have been saturated and distant markets will be served at higher line-mile costs. Without such benefits, development may never reach beyond 60 to 110 MW, even if discoveries are made elsewhere in zones 2 or 3, or even in zone 4.

Put simply, the return on development of relatively low-grade geothermal resouce may not be sufficiently attractive to attract either private or public dollars.

If development proceeds, the following scenario may be applicable:

Plant No.	Land	Capacity, MW	Year	Zone
1	Navy	10	1985	I
2	Public	50	1986	I
3	Navy	50	1987	I
4	Public	50	1991	II
5	Public	50	1995	I/II
6	Public	50	2000	II

No development is foreseen under this scenario in zones 3 and 4, nor to the full capacity believed possible in zones 1 and 2, by 1995. Some 210 MW of an anticipated 264 MW capacity in zones 1 and 2 (400 to 536 MW total field capacity) is considered likely to be developed by that date.

B.2.2.3.4 Field Management

The most critical problems facing development concern water supply (cooling, make-up), and maintenance of mass and pressure in the reservoir. To a degree these problems are interrelated, in that the lack of a policy of conserving geothermal fluid by reinjection will undoubtedly lead to problems of declining pressure and mass flow; and in that only by an alternate mode of cooling and/or by an alternate source of make-up water can there be adequate conservation of geothermal fluid.

Three actions can be taken to mitigate these problems. First, a policy of mandatory unitization can be adopted, in coordination with the U.S. Navy on its fee lands. Unitization would possibly allow a more balanced program of withdrawals and replacement of water at depth; it certainly would allow for coordinated studies of cause and effect of any changes in mass and pressure in wells.

Second, a program of hydrologic and reservoir measurements must be undertaken, beginning as soon as possible, and certainly including such items as:

A. Isotopic studies of deep geothermal fluid.

B. Measurements of potential interference in adjacent and distant wells.

C. Detailed measurements of porosity on cores and calculation of permeability from flow tests.

D. Shut-in pressure monitoring of deep wells.

E. Installation of a subsidence monitoring network.

F. Precision gravimetry surveys.

This could lead to much more accurate estimates of true consumptive demand, and thus to better decisions regarding allowable consumption.

Third, studies should begin regarding both alternate sources of water for cooling and alternate mode of power plant cooling, so that flash losses can be minimized and consumptive water requirements may be lessened. Obviously, this would add to the cost of geothermal power generation, and may be unacceptable to utilities. The alternative may be equally undesirable, if consumptive demand on the system leads to a shortened productive life.

Other management questions concern thermal decay of the field, potential ground subsidence accompanying withdrawal of fluid, and potential seismic and volcanic hazards. Subsidence, seismicity and volcanism probably would lend themselves to detailed monitoring by the U.S. Geological Survey in collaboration with the U.S. Navy, and possibly the State of California. Such studies could begin with establishment of first-order leveling and precision gravimetry networks, and the permanent installation of a seismometer network, with telemetry to a permanent observatory elsewhere.

Thermal decay of the field cannot be resolved at this time, because of the uncertainties regarding field porosity, permeability, recharge, and dimension. These questions cannot be answered until there are results of production tests on completed wells. As an initial statement, it can be argued that for rocks of 3 to 5% porosity, allowing for the greater specific heat of water relative to rock, at least 85% of the contained heat of the system water-rock is within the rock; and that even if all of the water were recovered by production wells (an unlikely assumption), the rock temperature would not have been reduced by any significant amount. Reinjection of thermally spent fluid might allow for secondary recovery of energy, but possibly at the cost of excessive cooling of the skin zone around fractures in the reservoir rock. This could result in degradation of the thermal system. However, if fractures are sufficiently interconnected as to allow for relatively free communication of reinjected geothermal fluid, there may be the potential for recovery of a second quotient of heat by producing the reinjected fluid a second time via wells without excess thermal decay. This requires more study.

B.2.3 Reservoir Development Model References

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B.3 Geothermal Energy Production Model

The material presented in this section describes the equipment which may be utilized in the generation of electrical energy using the geothermal fluid from the Coso area.

B.3.1 Assumptions and Physical Parameters

Based on the material presented in Section 2, the following assumptions are made:

1. The heat loss by well surface conduction can be neglected.
2. The well head pressure can be computed on the basis of the fluid enthalpy, fluid total dissolved solids (TDS), based on data in similar fields where the well head steam fraction is 10-20%.
3. The amount of fluid which can be reinjected through a well at reasonable pressures (50-150 psig), is about twice the production rate from similar wells in the area. Thus a reinjection well capacity of 400,000 lbs/hr is assummed.

The following physical parameters are utilized throughout this section:

1. Total dissolved solids (TDS), ppm = 6000-6500
2. Fluid enthalpy in reservoir, Btu/lb = 420-525
3. Fluid enthalpy at well head, Btu/lb = 420-525
4. Well head pressure, psia = 100-150
5. Well head temperature, ^{o}F = 355-375
6. Percentage of steam at well head = 12-21
7. Average fluid production per well, lb/hr = 200,000
8. Average reinjection capacity per well, lb/hr = 400,000

B.3.2 Geothermal Power Cycles

Several power cycles have been described in the literature of which only three will be considered here because of their near-term feasibility, high thermodynamic efficiency, and relatively low capital cost.

B.3.2.1 Direct-Flash Steam Cycle

Figure B.3-1 shows a simplified process schematic of a two-stage, direct-flash steam cycle. The well flow (usually two-phase) enters the first stage flash separator where steam is separated from the liquid; also, some liquid may be flashed into steam by lowering the pressure. The liquid then enters the second stage flash separator where pressure is lowered further and more liquid is flashed to produce low pressure steam. As the geothermal liquid passes through the two flash separators, it gives up most of its useful enthalphy in the form of high and low pressure steam. The spent liquid is then disposed of by reinjection. The high and low pressure steams are expanded to the condenser pressure in the steam turbines to produce mechanical work which drives the generator to produce electricity. The exhaust steam is condensed in a water-cooled, indirect-contact condenser. The condensate is utilized as makeup water for the cooling towers. The cooling tower blowdown is reinjected with the geothermal liquid.

The flashing may be done in one or more stages. The optimum number of flash stages depends upon the geothermal fluid characteristics and the size of the power plant. For a 50 MW power plant with the fluid characteristics described, two-stage flashing will be optimum from a cost point of view.

B.3.2.2 Steam-to-Isobutane Binary Cycle

A simplified process schematic of a steam-to-isobutane binary cycle is shown in Figure B.3-2. In this process also, the geothermal fluid is passed through two flash stages to produce high and low pressure steams. These steams are then utilized to evaporate isobutane. The evaporated (hot) isobutane is circulated in a closed loop in which it is expanded through an isobutane turbine, condensed in an indirect contact condenser, and pumped through an isobutane feed pump. The isobutane condenser is cooled, in turn, by a closed loop cooling water system which is cooled by a wet cooling tower. The condensate from the flashed steams is used for cooling tower makeup water.

As in the case of the direct-flash steam cycle, the geothermal fluid may be flashed in one or more stages. For a 50 MW power plant, two flash stages would be most cost effective. Also, there is a wide variety of fluids that may be used. The selection of the binary fluid depends upon the geothermal fluid characteristics. For the geothermal fluid assumed for the Coso

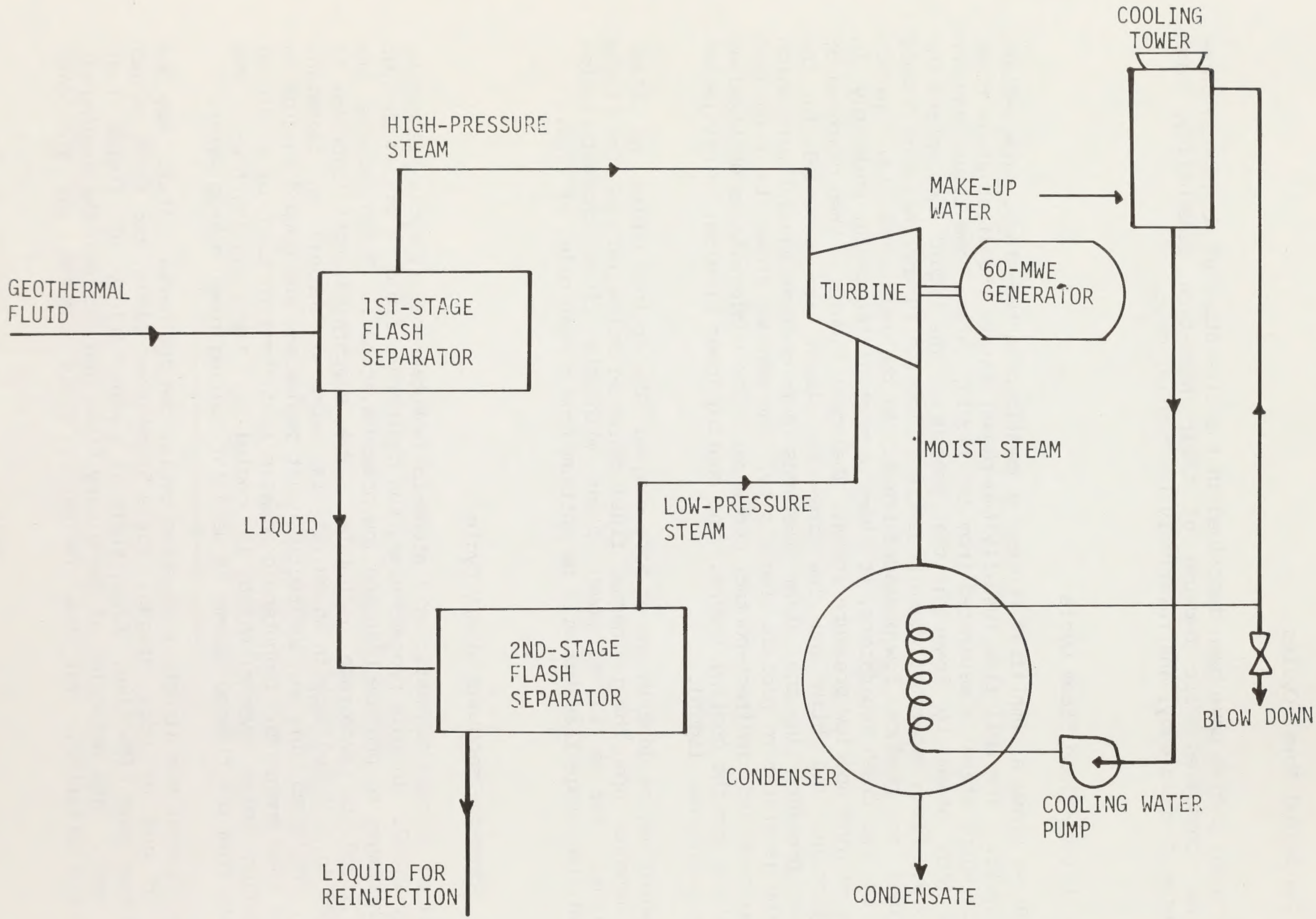

Figure B.3-1. DIRECT-FLASH STEAM CYCLE, 2-STAGE

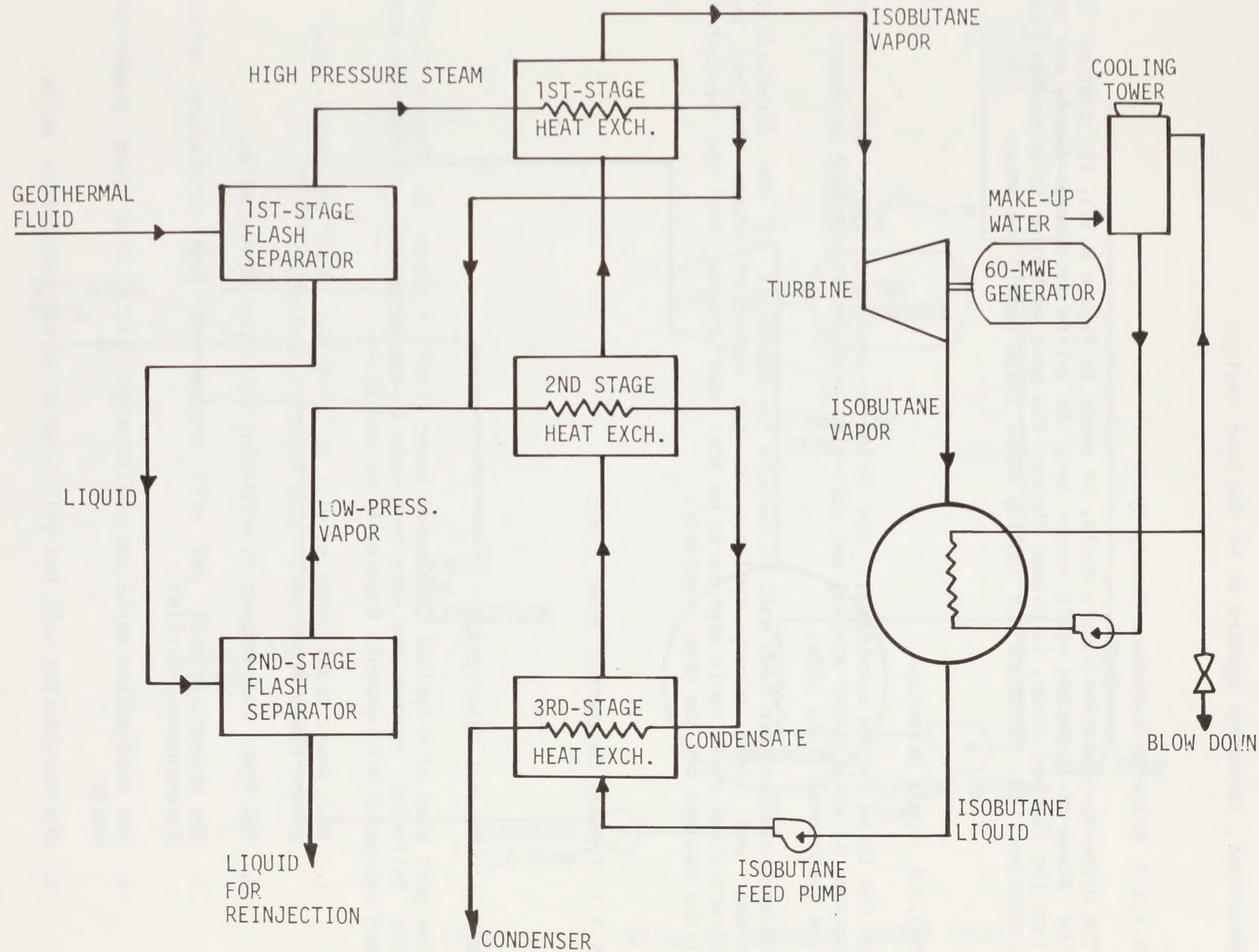

Figure B.3-2. STEAM-TO-ISOBUTANE BINARY CYCLE, 2-STAGE

Reservoir, isobutane appears to be the best choice.

B.3.2.3 Brine-to-Isobutane Binary Cycle

The brine-to-isobutane binary cycle, as shown in Figure B.3-3, is similar to the steam-to-isobutane cycle except that the entire geothermal fluid, and not just the flashed steam, is passed through the heat exchanger to evaporate the isobutane. The isobutane and cooling water loops remain the same.

B.3.2.4 Cycle Selection

Of the three cycles considered, the brine-to-isobutane cycle was rejected because of anticipated scaling and corrosion problems in the heat exchanger on the geothermal fluid side.

Several studies have been made to compare the economics of the direct-flash steam and steam binary cycles. On the basis of these studies, the direct-flash steam cycle appears to be the best choice for the geothermal fluid assumed for the Coso reservoir.

B.3.3 Typical Geothermal Power Plant

B.3.3.1 General Description

The plot plan of a typical geothermal power plant is shown in Figure B.3-4. The following assumptions have been made in the preparation of the plot plan and equipment arrangement, Figures B.3-5 and B.3-6.

1. Each power plant capacity will be 50 MW and will be based upon a direct flash steam cycle with indirect cooling.

2. The field can support 16 producing wells per square mile.

3. One production well pad will consist of four production wells, directionally drilled.

4. Two reinjection wells can handle waste brine from four production wells.

5. One reinjection well pad will consist of two reinjection wells.

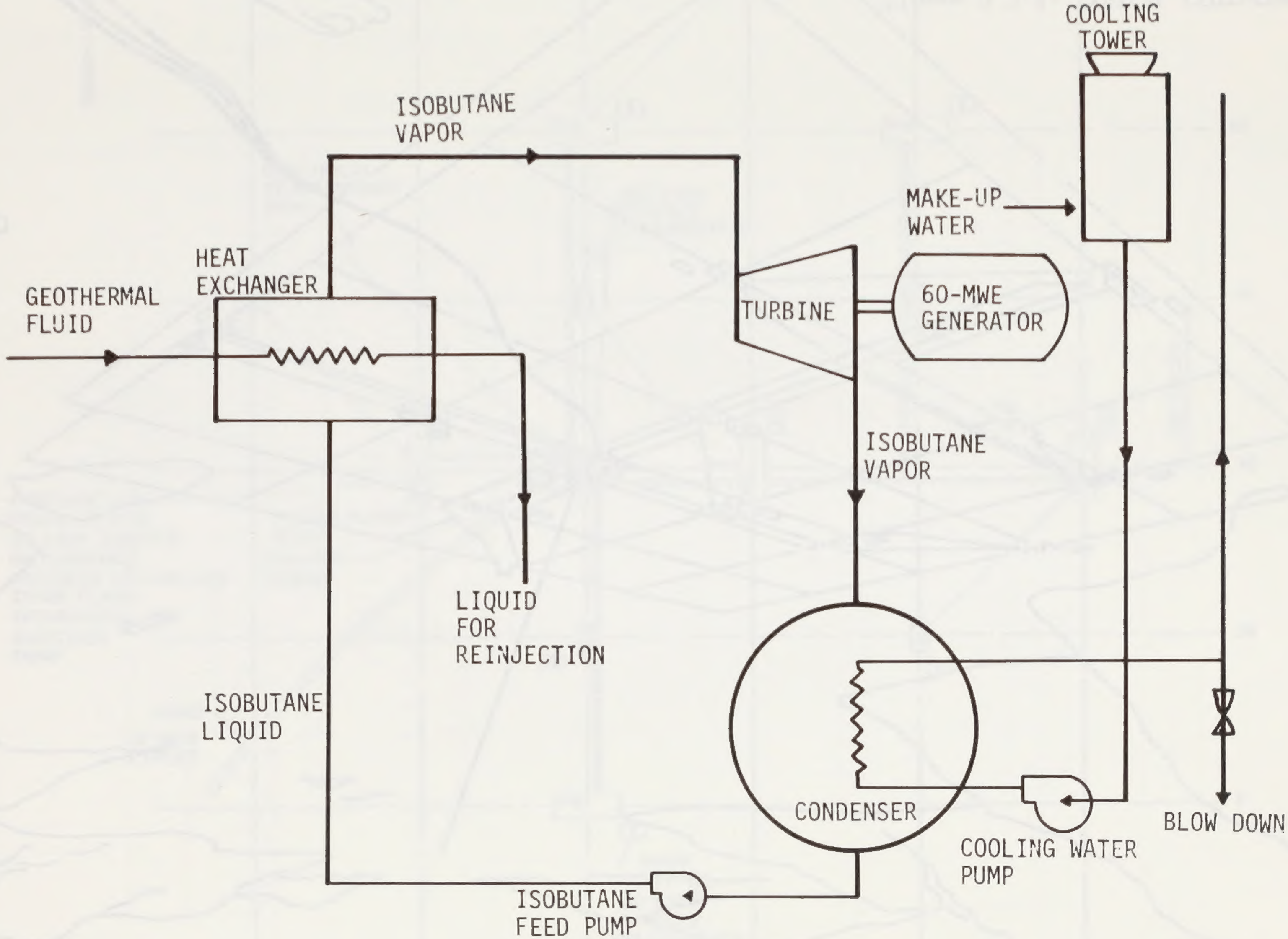

Figure B.3-3. BRINE TO ISOBUTANE BINARY CYCLE

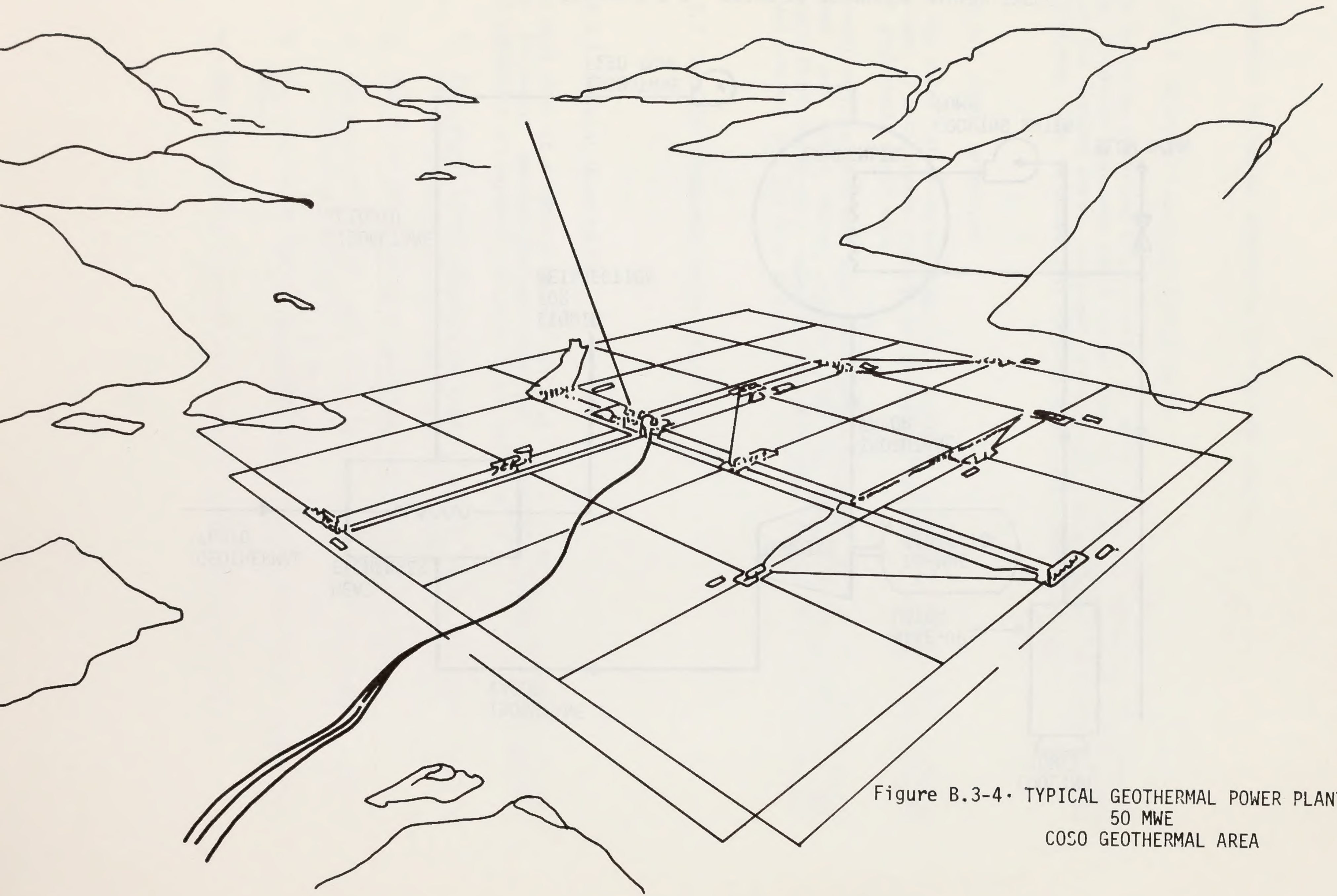

Figure B.3-4. TYPICAL GEOTHERMAL POWER PLANT
50 MWE
COSO GEOTHERMAL AREA

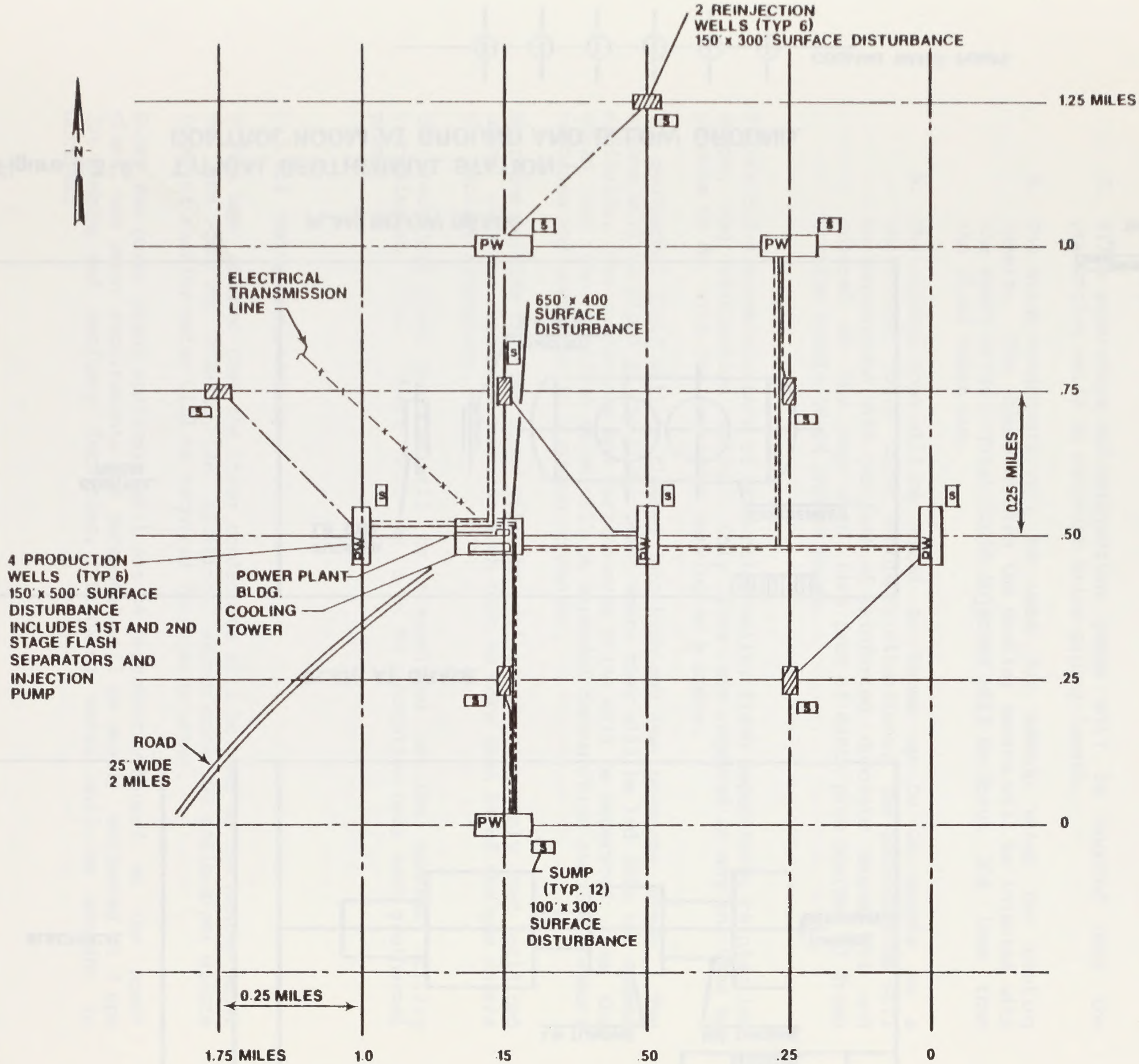

Figure B.3-5 TYPICAL PLOT PLAN FOR FIELD DEVELOPMENT

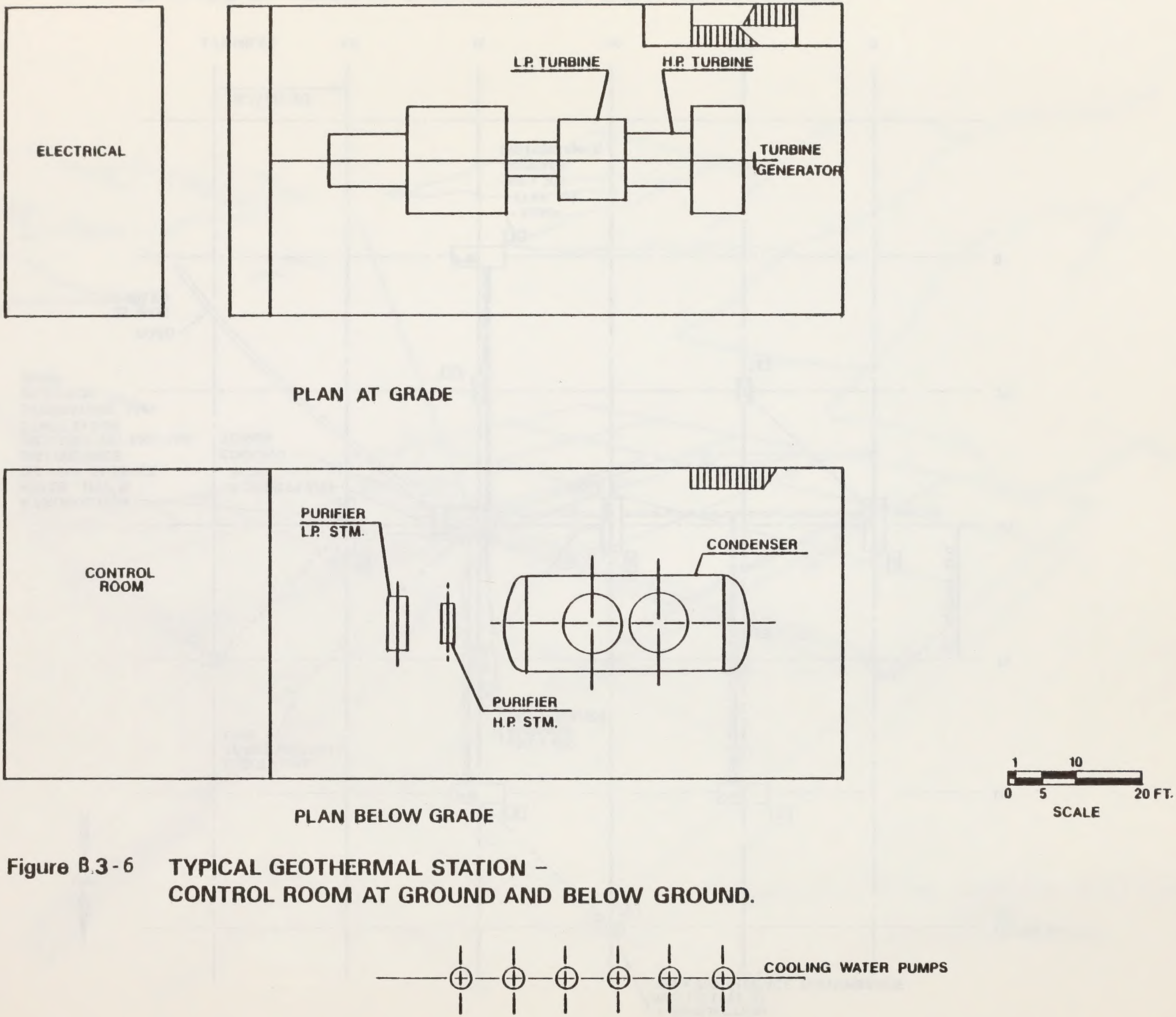

Figure B.3-6 TYPICAL GEOTHERMAL STATION – CONTROL ROOM AT GROUND AND BELOW GROUND.

6. As the wells deplete, more wells will be drilled and connected to the power plant.

7. Flash separators and reinjection pumps will be mounted near the production wells to minimize brine piping length.

8. The steam condensate will be used for makeup water for cooling towers. The blowdown from the cooling towers will be injected with the spent brine. Total fluid injected will be about 20% less than the fluid taken out.

9. The control room will be sized to house up to 20 people on a short-term basis under emergency situations. The control room will be underground with two feet of reinforced concrete around it and covered on the top with five feet of earth plus coarses of fresh granite rubble 18-24 inches thick.

Figure B.3-4 shows six sets of production wells, flash separators, reinjection pumps, and reinjection wells. Only five are required at any one time to produce 50 MW, with the remainder serving as a spare.

The geothermal fluid will be flashed into high and low pressure steam. The steams will be piped to the power plant where they will be led into two common manifolds. The condensate and carried-over brine will be separated from the steam and the purified steam will be expanded through high and low pressure turbines and condensed in a common condenser.

Hydrogen sulfide from the steam will be collected separately and oxidized using alkaline hydrogen peroxide such that no more than 5% of the gas enters the ambient atmosphere.

The electrical power produced will be transmitted to the nearest utility transmission line. There will be a 50 MW substation near each geothermal plant.

B.3.3.2 Water Requirements

It has been assumed that the steam condensate will be used as the makeup water for the cooling towers. An additional approximate 200 gallons per minute (gpm) of cooling water will be required for makeup water.

Since the power plant operators will not be permanently housed at the power plant, the water requirements for personnel will be small; estimated at 2 gpm for washing and sanitary faclities. Drinking water will be brought in bottles.

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Appendix C

C.1 MEMORANDUM OF UNDERSTANDING
Between
Naval Weapons Center, Department of Navy
Bureau of Land Management, Department of Interior

GEOTHERMAL LEASES IN COSO GEOTHERMAL AREA

It appearing that the Secretary of the Interior, acting through the California State Director, Bureau of Land Management (BLM) and the Department of the Navy, acting through the Commander, Naval Weapons Center (NWC), China Lake, California, have a mutual interest in certain real estate involving both acquired and/or withdrawn lands lying within and without the boundaries of NWC, and being generally within the subsurface to a circular surface area of a diameter of approximately forty-two (42) kilometers and centered at approximately 36° 05' latitude and 117° 50' W. longitude for the production of geothermal steam and associated geothermal resources. This area is depicted on the attached plat;

And it further appearing that although approximately the eastern sixty percent of this area lies within the boundaries of the NWC and, therefore, the surface of the area is under control and administration of the Department of the Navy, through the Commander, Naval Weapons Center; and that approximately the western forty percent of this area lies outside the boundaries of the NWC and, therefore, under the administration of the Department of the Interior, through BLM;

And it appearing that expeditious development and exploitation of geothermal steam and associated geothermal resources is of great importance to the United States, its agencies and its people;

And it also appearing that such development can be accomplished only with the highest degree of cooperation between the two governmental agencies which are parties hereto;

And it appearing that the NWC is an irreplaceable facility essential to the Navy in fulfilling its National Defense responsibilities;

And it appearing that it is in the National interest that there be orderly, optimum and expeditious development and expolitation of geothermal resources in the Coso area in such a manner that the NWC may continue to perform, fully, its National defense functions;

Therefore, it is deemed appropriate that this Memorandum of Understanding be entered into between the parties and their designated officials;

This Memorandum records the understanding of the parties as follows:

1. Public lands withdrawn for the purpose of the NWC defense mission shall be available for geothermal leasing upon NWC's written consent thereto with those stipulations determined necessary to make geothermal operations compatible with the mission of NWC. BLM will, to the extent authorized by applicable law, commit withdrawn lands within NWC to leases in accordance with mutually agreeable schedules.

2. NWC will proceed with its geothermal exploration and development program on acquired lands in the above-described area to provide a secure power supply for the Navy and to gain Navy expertise and experience in employment of this new energy source for support of military missions.

3. NWC and BLM shall cooperate in obtaining modifications to the applicable Public Land Orders to permit the leasing and development of geothermal resources on those lands described above. Jurisdiction over the subsurface and surface of NWC lands covered by this Memorandum necessary to permit development and exploration of the geothermal resources will be vested in the Secretary of the Interior, subject to such surface use controls and/or contraints as may be stipulated by NWC.

4. BLM agrees to coordinate lease stipulations for the public lands in proximity to the NWC lands with the Navy in consideration of the Navy's mission at NWC.

5. The parties agree to immediately take steps to determine methods under which NWC lands can legally be leased and to set forth schedules and programs for completing environmental analyses, leasing schedules, and methods of lease supervision and management of NWC lands, together with mutually acceptable lease conditions on adjacent public lands. Control of access, supervision of operations and handling of data shall be developed as part of lease terms and future agreements between the involved agencies. Lands within the NWC withdrawn area will be withheld from leasing until appropriate terms for development, utilization, or management are approved by the Navy.

6. In general, BLM and NWC agree to fully support each other in this mutual effort, and specifically, to support each other as necessary to accomplish the fullest development of the resource. BLM and NWC agree to cooperate in the development of terms and conditions which will enable lessee operations and NWC operations for exploration and production of geothermal resources in a compatible manner, including but not limited to, utilization, procedures and/or joint development.

7. It is mutually understood by BLM and NWC that the Commander, Naval Weapons Center does not have quthority to fully implement this agreement and that NWC will expeditiously request that authority.

8. It is mutually understood by BLM and NWC that the surface use controls and/or constraints will be identified per paragraph 3, within approximately 60 days of the the execution of this agreement. Those stipulations will then be made a part of this MOU by amendment. It is further understood

that after the initial 60 day period, any emerging control/constraint necessary to prevent an adverse impact on the NWC mission will be incorporated into the BLM leases.

DATED: Dec. 6, 1977 W. L. Harris

Commander, Naval Weapons Center
China Lake, California
DEPARTMENT OF THE NAVY

DATED: Nov. 30, 1977 Ed Hastey

State Director, Bureau of Land Management
California
DEPARTMENT OF THE INTERIOR

Pursuant to the MOU is an addendum regarding constraints on geothermal operations on NWC lands. This constraints package is in draft form and subject to change.

APPENDIX C

C.2 NAVY CONSTRAINTS ON GEOTHERMAL OPERATIONS ON NWC LANDS

.1 General

Constraints will be placed on geothermal operations, within the boundaries of the Naval Weapons Center, to ensure the safe and economical development and production of those geothermal resources within the NWC boundary, and ensure that any leasing, development, or production does not conflict with the mission of the NWC.

.2 Administrative Responsibility

The Commander, NWC, is the responsible agent of the Federal Government for the utilization of the land and airspace of the NWC. As such, the Commander, NWC, is responsible for the protection of the health and safety of all personnel, military and civilian, within the confines of NWC, and is responsible for the continuing preservation of the ability of NWC to perform its mission of Air Weapons RDT&E.

.3 Access

Access to the NWC is a privilege granted by the Commander, NWC. Exercise of this privilege requires adherence to the NWC traffic regulations, check in/check out procedures, radiation control measures, environmental controls, area access limitations, electronic emission controls, and such other published administrative regulations as appropriate. Access shall be on a not-to-interfere basis with NWC test schedules, and shall be limited to that specific lease block or area being explored, developed or produced. Access schedules shall be established on a weekly basis with NWC. NWC shall provide for emergency access, for reasons of geothermal safety or other drilling incidents requiring uninterrupted short term access, to a specific site or geothermal operation. Experience to date shows, in any given month, unscheduled daylight downtime will not regularly exceed 10%, and unscheduled nighttime downtime will not regularly exceed 2%. Access shall require that for each leaseholder, one responsible contact point shall at all times know who is present on NWC lands, and this contact point shall be reachable at all times in the event an evacuation is ordered.

.4 Security

The mission of the NWC is such that visitors cannot be granted access to NWC lands without going through NWC security procedures. All non-citizen visits must be arranged through NWC with a minimum notice of 48 hours for non-communist-bloc visitors. The latter will be considered on a case-by-case basis. The accessible areas and routes to and from work areas within lease blocks shall be approved by NWC.

.5 Vehicular Usage

All vehicular traffic shall be limited to routes approved by NWC. NWC retains the right to suspend any operation that, judged by the Center, presents an imminent threat to the environment. During all operations, all Federal, state and local environmental requirements shall be rigorously observed. No components of the environment shall be unnecessarily disturbed. NWC shall have the right to impose those emission standards requried to protect the Center`s mission.

.6 Sites and Routes

Power plant sites, drill pad sites, and pipeline routes will be selected subject to NWC approval to ensure such sites will have a minimum impact on NWC range operations. All site plans shall be submitted to NWC for review and approval.

.7 Shelters

Lease operators shall have the option of either removing their employees from NWC upon request or retiring to NWC approved personnel shelters provided by the contractor during those times when the NWC mission requires personnel protection at the work site.

.8 Radioactive Sources

No radioactive sources shall be brought onto NWC until appropriate Navy permits have been obtained. These permits will be issued once NWC has verified the license of the operator to be valid for the proposed effort, and approved written standard procedures for use and for handling lost or damaged sources.

.9 Injuries and Accidents

All disabling injuries occurring on NWC land will be reported within 24 hours to NWC. NWC will retain the right to suspend any operation judged by NWC to present an imminent danger to any personnel on NWC property or to government property.

.10 Electronic Radiation

Electronic emissions will not be permitted without prior review and authorization by the NWC. Periods of emission will be coordinated with the Center and, at times, the Center may require electronic emission silence for periods of up to four hours.

.11 Plant Protection

All well heads shall be revetted to a degree acceptable to NWC; all wells shall be fitted with an approved below ground flow limiter; all pipe lines shall have automatic flow limiters as approved by NWC, and all power plants shall be equipped with a hardened control room approved for continuous occupancy during NWC tests.

.12 Information

All information on incidents involving NWC equipment and/or personnel associated with the geothermal operations will be released to the public by NWC or jointly by NWC and the geothermal operator. Particular attention will be given to information concerning incidents that have the potential for high public interest. Any serious injury or fatality and any geothermal blowout will be reported at once to NWC.

.13 Military/Government Property

All military and government property found on the land surface or embedded in the land shall be left in place. NWC shall be informed of the presence of all suspected or potentially hazardous material immediately and NWC personnel will inspect and remove such material in a timely manner. In case of doubt, NWC is to be called for an inspection.

.14 Data Exchange

Data on flow, chemistry of fluids, and reservoir conditions and structure shall be provided to NWC with such data to remain proprietary for a mutually agreed time, and in no case to exceed 10 years.

.15 Legal Jurisdiction

Law enforcement on NWC lands will remain the responsibility of NWC. The use of geothermal operator employees in a guard function or the contracting by the geothermal operator for security guards on NWC lands will be subject to review and approval by NWC.

.16 Right of Inspection

NWC shall have the right of inspection at all times to ensure and verify compliance with these constraints.

.17 Resource Production

All production plans including reinjection schedules shall be submitted to NAVWPNCEN for the record and any such activities that show a reasonable probability of damaging or decreasing the productivity of NAVWPNCEN fee lands shall be prohibited unless such operations and the NAVWPNCEN fee lands involved are both covered by and operated under the same producing unit agreement.

The procedures outlined in the agreement are intended to supplement the cooperative procedures between BLM, GS, and the U.S. Fish and Wildlife Service (FWS) as formally established in June 1976. The provisions of this cultural resource protection agreement will be reviewed at least annually and revised as necessary to improve their workability and will be incorporated into any revision of the BLM, GS, and FWS Cooperative Procedures Agreement of June 1976.

The cultural resource protection procedures as outlined in this agreement are intended to increase cooperation between the Bureaus, avoid duplication of work, and promoted more efficient use of field personnel. It is essential that supervisors of both agencies take the lead in assuring that the procedures of this agreement are carried out. To facilitate the annual review of this agreement supervisors should, after an appropriate period of operating experience under the term of the agreement, notify the co-chairman of desirable changes or additions.

C.3 COOPERATIVE PROCEDURES

U.S. Geological Survey and Bureau of Land Management

Protection of Cultural Resources Related to Geothermal Lease Operations

Introduction and Purpose

This agreement establishes cooperative procedures between the Bureau of Land Management (BLM) and the U.S. Geological Survey (GS) for the protection of cultural resources from surface disturbing activities related to Federal geothermal lease operations. This agreement sets forth the respective functions and responsibilities of the two agencies on public lands where BLM is the responsible surface management agency and on private surface where Federal reserved minerals are involved.

BLM and GS have concluded the following:

1. Compliance with the National Historic Preservation Act of 1966 (NHPA), as amended, and Executive Order 11593 is mandatory for both agencies.

2. There is a need to consider cultural resources in the earliest planning stages of development in order to minimize delays in the exploration and development of geothermal resources.

3. Long-term management continuity for cultural resources should be addressed in all aspects of planning and policy decisions.

4. There is a need to ensure that cultural resources are not inadvertently injured or destroyed by geothermal operations and related activities.

5. There is a need to achieve and maintain consistency in the application of cultural resource management requirements and stipulations related to geothermal lease operations.

6. There is a need for interface procedures between BLM and GS that will permit the timely processing of applications to conduct geothermal operations.

7. There is a need, in the consideration of applications to conduct operations, to integrate the data collection requirements of the National Environmental Policy Act of 1969 (NEPA), as amended, and section 106 of NHPA of 1966, as amended, to avoid delay and duplication of effort in cultural resource protection.

Definitions

Avoidance is the partial or complete redesign or relocation of a project or action to eliminate the potential of impact to a cultural resource. If avoidance cannot be insured, then appropriate mitigation must be undertaken. (See mitigation.)

BLM/GS Program Coordination Committee is an intradepartmental committee established to provide a formal vehicle for program coordination between BLM and GS. Co-chaired by the Associate Director, BLM, and the Associate Director, GS, the committe consists of directorate level representatives from the two Bureaus; plus appropriate subcommittees. The committee meets monthly in Washington, D.C.

Cultural resources are those fragile and nonrenewable remains of human activity, occupation, and endeavor as reflected in districts, sites, and natural features that were of importance in human events. These resources consist of (a) physical remains, (b) areas where significant human events occurred--even though physical evidence of the event no longer remains, and (c) the environment surrounding the actual resource. Cultural resources include both prehistoric and historic remains.

Data recovery is the systematic gathering of the scientific, prehistoric, historic, and/or archeological data that provide a cultural resource property with its research and data value.

Mitigation is the alleviation or lessening of possible adverse effects of the action upon a cultural resource by application of appropriate protection measures. Mitigation may include detailed recordation and documentation, surface collection, subsurface sampling, salvage, and/or relocation of the resource. The nature of the mitigation is dependent upon the impact and the scientific and sociocultural value of the cultural resource involved.

Scientific value is the importance attributed to a cultural resource by scientists and historians because of the information it contains, which will contribute to the understanding of human behavior.

Sociocultural value is the importance attributed to an object, structure, place, living thing, lifestyle, or belief by a group based on the group's perception of the object's role in maintaining their heritage or their existence as a group. Sociocultural values are usually expressed in qualitative, rather than quantitative, terms.

Principles of Agreements

Therefore, BLM and GS mutually agree to the following:

1. The procedures outlined herein supplement the cooperative procedures between BLM, GS and the U.S. Fish and Wildlife Service (FWS) as formally established in June 1976; however, in case of any conflict or inconsistency with regard to cultural resources, the provisions of this agreement shall prevail.

2. A memorandum of Understanding between BLM, GS, and the Advisory Council on Historic Preservation (ACHP), pursuant to section 106 of NHPA, as amended, will be developed based, in part, on the procedures outlined herein.

3. Since the compliance process of both NEPA and section 106 of NHPA, requires similar data, these two requirements will be integrated, whenever possible, so that data generated may be used as documentation for both.

4. Impacts on cultural resources shall be avoided or mitigated.

5. Because BLM has cultural resource expertise, GS will rely on BLM to provide the cultural resource protection requirements related to geothermal lease operations and to coordinate cultural resource compliance responsibilities, including National Register of Historic Places eligibility determinations, consultation with the State Historic Preservation Officer (SHPO), and completion of section 106 of NHPA compliance. This will be superseded by any Memorandum of Understanding developed pursuant to item 2, above.

6. On leases where BLM is the surface management agency or where Federal reserved minerals are involved, GS is responsible for enforcement of compliance with the BLM's cultural resource protection requirements within the area of operations. Accordingly, BLM may make field examinations and report infractions to the Area Geothermal Supervisor and otherwise aid GS in carrying out its enforcement responsibilities in this regard. If the Authorized Officer, BLM, or his designee, discovers that an operator is conductiong activities which are not in compliance with cultural resource protection requirements of the lease terms, the approved permit to drill, applicable geothermal operating regulations and orders, or the approved Plan of Operation, and that such activities pose a threat to the preservation and integrity of the cultural resources, and a representative of the Area Geothermal Supervisor is not timely available, the Authorized Officer, BLM, may order the immediate cessation of such activities and shall promptly notify the Area Geothermal Supervisor.

7. If BLM and GS encounter difficulties at the field level in achieving agreement as to the necessary requirements for the protection of cultural resources, the problems will be referred to the BLM-GS Program Coordination Committee for resolution.

8. The provisions of this agreement shall be reviewed by the BLM-GS Program Coordination Committee at least annually and revised, as necessary, to improve their workability and shall be incorporated into any revision of the cooperative procedures between GLM, GS, and FWS, as formally established in June 1976.

Procedures

In furtherance of the general concepts listed above, BLM and GS agree to the following procedures to ensure cultural resource protection for geothermal leasing and operations over which BLM and GS exercise joint responsibilities.

1. BLM will include a special stipulation for the identification and protection of cultural resources in all new and renewed geothermal leases, specifying the following points:

a. The certified statement required by section 18 of the lease form must be completed by a qualified cultural resource specialist acceptable to the Authorized Officer, BLM; and

b. When necessary, additional special cultural resource stipulations and/or restrictions may be imposed by BLM and GS.

2. GS will not grant relief to the lessee or operator from any part of these stipulations without approval by the Authorized Officer, BLM.

3. Through the use of a Notice to Lessee (NTL) or other means, GS will do the following:

a. Inform the lessee or operator that a cultural resource inventory of the area(s) to be disturbed must be performed and that the cost of the cultural resource inventory and report will be borne by the lessee;

b. Instruct the lessee or operator that the boundaries of the areas to be disturbed must be staked prior to conductiong the cultural resource inventory; and

c. Refer the lessee or operator to the Authorized Officer, BLM, for specific information regarding cultural resource inventory and report standards.

4. GS will insure that the cultural resource inventory report will be included as part of the Plan of Operation submitted to the Area Geothermal Supervisor, and forward a copy of the Plan of Operation and the cultural resource inventory report to the Authorized Officer, BLM.

Upon receipt of the Plan of Operation, BLM will do the following:

a. Review the report for acceptability; and

b. Advise GS within 10 working days that-

(1) The report is acceptable, or

(2) The report must be supplemented.

6. Upon receipt of comment from BLM regarding the adequacy of the cultural resource inventory report, GS will notify the lessee or operator of the following:

a. The report is acceptable; or

b. The lessee or operator, at its own expense, is required to perform additional work to supplement the cultural resource inventory report.

7. Upon receipt of an acceptable cultural resource inventory report and after reviewing the Plan of Operation, GLM will do the following:

a. Determine avoidance requirements and necessary mitigation, and prepare special stipulations designed to ensure compliance with Federal Cultural resource protection regulations, including consulting with the SHPO and completion of section 106 of NHPA compliance; and

b. Provide GS with the determined avoidance requirements, necessary mitigations, and special stipulations within 30 days of BLM's receipt of the acceptable cultural resource inventory report, unless an extension is requested by BLM.

8. Although BLM is the lead agency in matters pertaining to section 106 of NHPA compliance, when time is of great importance, GS, with BLM concurrence, may provide assistance in the consultation process.

9. GS will inform the lessee or operator of avoidance requirements, necessary mitigations, and special stipulations identified in item 7 above, and incorporate them in the approved Plan of Operation. Mitigation of impacts to known cultural resources must be completed before surface disturbance begins in the immediate area of such resources. All mitigation costs associated with the protection of cultural resources identified prior to the commencement of operations will be borne by the lessee or operator.

10. GS will refer the lessee or operator to an appropriate BLM officer for clarification of questions regarding mitigation of impacts to cultural resouces.

11. In the event of a discovery of previously unknown cultural resources during operational activities conducted under an approved plan or permit the following actions shall occur:

a. The lessee or operator will stop operations in the immediate area of the discovery and shall immediately notify GS, or BLM if unable to contact GS, of the cultural resource discovery;

b. GS will instruct the operator to suspend operational activities in the immediate area of the cultural resource and will immediately notify the Authorized Officer, BLM, of the discovery. If GS is not immediately available, BLM may direct a suspension of operations and immediately notify GS of such an action; and

c. The Authorized Officer, BLM, will evaluate, or have evaluated, all previously unknown cultural resources brought to his attention and will advise GS, within 48 hours of being notified, of any action that may be required to protect or preserve each discovery. GS will immediately notify the operator of any actions that must be taken prior to the resumption of operations in the discovery area. Responsibility for, and cost of, data recovery of such cultural values discovered during operations will be borne by the lessee.

Arnold E. Petty 6/22/78

Acting Director, Bureau of Land Management
Arnold E. Petty
Date

W. A. Radlinski 6/2/78

Acting Director, U.S. Geological Survey
W. A. Radlinski
Date

APPENDIX D

MONITORING PLANS

D.1 SOILS

A soils monitoring program is presented to provide a means of assessing changes over time in the soil resources of the Coso Geothermal Study Area.

To provide a check of ongoing soil erosion which has resulted from geothermal activities, photographic documentation of actively eroding soil areas should be carried out on an annual basis. This documentation may be implemented by the lease field developer or the BLM at the end of the rainy season. Actual measurement of depth, width, and length of rills and gullies should be carried out to determine if changes in size are occurring over time. Photo documentation is applicable to all stages of the proposed action, and shall also serve as a means of monitoring the effectiveness of implemented soil mitigation measures.

To monitor the effects of cooling tower emissions on soils, a sampling scheme is presented as follows:

1. Soils should be sampled annually by the lease field developer or the BLM at the end of the rainy season.

2. Permanent marker pins should be located every 1,000 feet along a transect extending in the same compass direction and located in coordination with the air quality monitoring devices. This transect will extend approximately one to three miles downwind from a power plant The transect sampling scheme should be implemented prior to the field development stage as described in the proposed action.

3. Method of Sampling

   A. Ten individual soil samples should be taken within a 10-meter radius of each marker pin.

   B. Samples should be taken with an Oakfield stainless steel soil sampling tube (or equivalent) of the surface A horizon of the soil regardless of soil type.

   C. The 10 satellite samples should be composited and mixed thoroughly, then stored in double thickness one-gallon zip-loc bags. An approximately 500-gram subsampler per marker pin should be collected.

D. An additional samples should be taken at each marker pin for mercury analysis. This soil sample should be collected at a depth of four to six inches. If the soil sample is dry, it should be sieved to -80 mesh in the field, using a stainless steel sieve, and stored in an air-tight screw top glass vial. Wet samples should be dried at room temperature or in the shade before sieving. A small quantity of soil is adequate.

4. Soil samples should be transported carefully and submitted for analysis within five days of collection. Laboratory analysis of the soil samples should be undertaken for the following constituents:

   A. Boron

   B. Chlorides

   C. Sulfur

   D. Mercury, using a Jerome Instrument Corporation, Gold Film Mercury Detector (or equivalent).

In addition, the soil samples should be characterized for pH, electrical conductivity, and sodium absorption ratio.

D.2 MONITORING PLAN: WILDLIFE AND FLORA

A comprehensive plan for ecosystem monitoring is essential for proper mitigation of impacts to both wildlife and flora. (These two resources have been grouped together for efficiency as suggested in the Request for Proposal.) The plan is designed to determine whether the impacts of the proposed action were accurately assessed in the FES, and whether mitigation measures proposed are proving effective, including the rehabilitation efforts at the site. This plan should include the following components:

1. The amount of habitat lost for each lease tract should be checked by comparing aerial photographs taken upon completion of each power plant with those used in preparation for the Flora Technical Report or by counting acreage of the mapped areas disturbance. The former method would provide the most accurate information but it would also be more expensive. Either method will allow a determination of the type and amount of habitat lost and will aid in mitigation. The amount of revegetation of road cuts and other disturbed areas needed to compensate for lost wildlife habitat can thus be determined from these before-and-after floral analyses.

2. Population monitoring is required on a regular basis when a phased project of this magnitude is carried out. Also, the rare Mohave ground squirrel appears to be particularly abundant on almost every part of the CGSA. More Mohave ground squirrels have been caught in this study than in all previous field studies combined (see Wildlife Technical Report: Rodents). It is therefore essential to determine accurate population density measurements for this rare species, particularly in the areas of high and medium geothermal potential (Zones 1 and 2). After construction is completed, a second population study will allow success of the mitigation program for the species to be evaluated.

3. A careful census of current raptor nesting sites and carnivore denning areas would be necessary as a part of the required site-specific analyses for each Plan of Operation. Location of noise-producing equipment should be at least one-half mile from these highly sensitive wildlife species.

4. An analysis of the geothermal fluid must be made to determine if toxic substances are presents (see 5, below). Measurements of cooling tower emissions for mercury and hydrogen sulfide must be made at appropriate downwind locations. Vegetation and animal life (both invertebrates such as millipedes and vertebrates such as rodents) should be sampled and examined for toxic substances before operations begin; this activity should be coordinated with the Soils Monitoring Plan to determine baseline concentrations of mercury, sulfur and possibly other elements that may occur in the geothermal fluid. These concentrations should be monitored every one to two years during the first 10 years of operation in order to detect

accumulations that might be related to cooling tower emissions. Analyses of both plants and animals are necessary, since organisms have been found to concentrate mercury from 10 to 100 times the levels found in the soils.

5. When analyses in item 4 are carried out, the physiological condition of the vegetation near power plants and at some distance downwind should be assessed visually or with aerial photography with false-color film. This assessment will allow areas of stressed vegetation to be detected and should be repeated each season when photosynthetic activity is highest.

6. Water levels for Little Lake, Haiwee Spring and Coso Hot Springs as well as chemical analyses of both geothermal and non-geothermal waters are included in the Hydrology Monitoring Plan. If change in water level or the chemistry of aquatic habitats occurs, vegetation as well as aquatic invertebrates and fish may be affected. Since baseline data of aquatic flora and fauna are known (Wildlife and Flora Technical Reports), spot checks can be carried out at appropriate times to determine if these populations have been affected.

D.3 AIR QUALITY MONITORING PLAN

1.0 INTRODUCTION

The ambient pollutant concentrations predicted in the Air Quality Technical Report are all based upon dispersion modeling results obtained using the emissions estimates described Chapter 1 of the ES as inputs. There is uncertainty in these predicted concentrations from two sources.

First, the simulation models are inherently imprecise, providing only an approximate mathematical description of the pollutant dispersion processess.

Second, the inputs to the models used in the Coso study are estimate values. The meteorological inputs had to be partially extrapolated from China Lake data because a complete meteorological data base has not been compiled for the Coso area. Furthermore, the emissions inputs are estimates based upon data from other geothermal fields and upon limited field testing data taken in the Coso KGRA. Also, the total production capacity of the field has been estimated conservatively and may be significantly greater than projected in Chapter 1 of the ES.

Because of these multiple uncertainties, it will be necessary to maintain a constant check on ambient pollutant levels as geothermal development proceeds in order to determine whether or not further mitigation will be required to meet applicable air quality standards and avoid impact on other environmental resources.

2.0 METEOROLOGICAL MONITORING

The placement of ambient pollutant monitoring instruments is dictated largely by meteorological parameters. The lack of a complete meteorological data base, however, makes it difficult to choose such monitoring sites effectively in the Coso KGRA. Therefore, a high priority in the overall monitoring plan should be the installation of a meteorological data collection system. A basic system would, at minimum, consist of wind speed, wind direction and temperature sensors along with the associated data acquisition equipment. These to be placed at locations where high ambient pollutant concentrations might be expected due to frequent inversions or other prevailing stable conditions. Depending on actual power plant sites chosen, such locations might include Rose Valley, Devil's Kitchen, and Coso Basin. Two or three additional wind stations can be included to cover the the KGRA uniformly. The China Lake NWC staff presently operates winds stations at Rose Valley Ranch, Coso Basin, and Haiwee Dam, and it may be possible to include these data into the overall database.

Inversion height data in the KGRA are extremely rare. The only data available are acoustic sounder data collected Rose Valley Ranch during January, February, and March, 1979. Only the lowest inversion was analyzed, the instrument maximum height being 1,000 meters. The nearest rawinsonde data available were collected intermittently during 1964 and 1965 at Tower 8 in Indian Wells Valley, approximately 20 miles from Coso Hot Springs. Because mixing height is an important input to the dispersion models, acoustic sounders should be operated continuously for at least one year at Coso Basin and in Rose Valley. These sites are chosen because they should be particularly susceptible to strong inversions, especially during the winter months.

3.0 POLLUTANT MONITORING

The dispersion modeling effort described in the Air Quality Technical Report has predicted ambient levels of hydrogen sulfide and fugitive dust to exceed Federal and/or State standards under certain meteorological conditions and during certain stages of geothermal development. Commercial hydrogen sulfide sensors are available for continuous monitoring of this species. As the power plants are expected to be the largest continuous source of hydrogen sulfide, monitoring stations should initially be placed near each power plant as it is brought on line. It should not be necessary to purchase a complete monitoring system for each power plant; if a year or two of monitoring data shows that hydrogen sulfide standards are not being exceeded near the plant, then the monitors can be moved to the next new plant in the development and the process can be repeated. It is critical, however, that the monitoring stations be placed in the areas of most probable maximum concentration. Considering the predominant wind directions in the Coso area, one station should be placed to the north-northwest, and one to the south-southwest of each source. For H_2S emitted from power plants under most meteorological conditions, the stations should be placed approximately 0.5 km from each plant.

Monitoring total suspended particulate (TSP) concentration should be a good approximation of fugitive dust levels, as dust will be the largest constituent by weight of TSP. High-volume samplers for TSP monitoring are available commercially and are described in the Code of Federal Regulations (40 CFR 50). Construction areas and heavily traveled unpaved roads will be the greatest dust emission sources, so monitors should be placed nearby. The monitoring system can be moved as the zones of construction and heavy traffic shift during the staged geothermal development. As with H_2S, the TSP monitors should be placed to the north-northwest and south-southwest of major emission sources, but here the distance should be approximately one kilometer from the center of the disturbed area.

In addition to the hydrogen sulfide and TSP sensors placed near emission sources to monitor local concentration maxima, several monitoring stations should also be located throughout the KGRA to characterize mesoscale concentration patterns. These monitors should be placed in areas subject to meteorological conditions (such as strong inversions) which can lead to adverse air pollution episodes. Probable locations include Rose Valley and Coso Basin. The placement of these monitors should be correlated with the results of the meteorological monitoring program.

The exact placement of all of the monitoring devices discussed here will have to be decided on a case-by-case basis. Local topography, meteorology, and availability of electrical power can all affect the decision. Useful guidelines are available in the Federal Air Quality Surveillance Regulations (EPA, 1979)

The monitoring results should all be considered in terms of the State of California and Federal ambient air quality standards listed in the Air Quality Technical Report (*). Hydrogen sulfide data should be compiled as one-hour averages to conform to the California State standards. Stronger mitigation measures than those currently required should be considered if any of the standards are violated.

4.0 TRACE ELEMENT MONITORING

Trace amounts of various elements have been found in previously developed geothermal fields. Monitoring of ambient trace element levels may be advisable at Coso, but this should be decided on a case-by-case basis due to the wide variability of concentrations both within a given field and among seperate fields. Tests of the geothermal fluid should reveal the predominant trace elements present, and monitoring plans can be developed accordingly, if found necessary. If mercury (Hg) in the geothermal fluid is consistently found to be greater than 10^{-7} of the total weight then, according to dispersion model estimates, it is possible that the ambient mercury levels will exceed 0.1 ug/m^3. This exposure is believed to cause damage to plants and animals (including humans), so a monitoring program should be implemented. As with other monitoring devices, trace element monitors should be placed near the emission sources as well as in areas such as Rose Valley and Coso Basin which are subject to adverse meteorological conditions and concurrent high pollutant concentrations.

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* It should be noted that the regulations concerning the monitoring are under litigation. Recent court decisions indicate that other species may require monitoring.

5.0 VISIBILITY MONITORING

Maintenance of good visibility in the Coso Area is of prime concern to the NWC with respect to its mission. In addition, the proximity of the CGSA to Class I areas suggests that visibility be monitored to insure that this resource is not significantly degraded. Neither the State of California or the EPA have promulgated guidelines or regulations concerning how visibility shall be quantified.

As the primary concern in the area is long range visibility (greater than 40 kilometers) it is recommended that a monitoring program using the telephotometric technique be established. It is recommended that one telephotometer site be located in the Indian Wells valley and that another site be established at location to be agreed upon with the National Park Service. This program should commence at least one year prior to initiation of development to provide a good baseline against which to measure the impact of the geothermal development.

Reference

Environmental Protection Agency Ambient Air Quality Surveillance Regulations (40 CFR 58; 44 FR 27571, May 10, 1979).

COSO ENVIRONMENTAL STATEMENT

D.4 HYDROLOGY MONITORING PLAN

TABLE OF CONTENTS

Monitoring plans to enable assessment of potential hydrologic impacts in the Coso Geothermal Study Area (CGSA) fall into four categories:

1. Water quality monitoring
2. Water level monitoring, and
3. Coso Hot Springs monitoring
4. Geothermal reservoir monitoring

Each of these monitoring plans must begin with a viable baseline established prior to development. The leasees, either individually or jointly, will be responsible for implementation of the plan and baseline survey. The baseline and outlines for subsequent monitoring for each of the above categories is discussed below.

1.0 WATER QUALITY

For ground or surface water degradation assessment, the natural or current characteristics of the water must be defined and potential degradation sources should be identified. It is important to establish reliable and representative baseline water quality data since adverse changes in water chemistry provide the prima facie evidence of degradation. This often requires collection and analysis of several water samples at representative locations over a period of time. Future analyses would be compared with the baseline data to determine if any changes have occurred. When potential degradation sources have been identified, mitigation measures should be taken.

To monitor for changes in ground water characteristics that may occur during geothermal development and injection the baseline conditions that must be established include:

a. chemical characteristics of nongeothermal ground water, geothermal ground water, and surface waters;

b. geology and hydrology of the area;

c. location, well use and well completion data for all wells in and around the geothermal site; and

d. mechanics and characteristics of the geothermal system.

These data have been compiled and interpreted for the CGSA, to the degree that available information allows, in the geology and hydrology technical reports. Well and spring data appear in Hydrology Technical Report Appendix B and chemical analyses appear in Appendix C.

Current chemical data must also be collected for all waters in the area, including geothermal and nongeothermal ground water, surface water, and any other disposed water to augment existing data and provide a reliable, consistent baseline. The goal of this data collection is to establish for each water type (including industrial and agricultural releases):

1) chemical characteristics;

2) three-dimensional (spatial) distribution;

3) natural temporal variations or cycles;

4) in conjunction with the geologic data, chemical reactions and changes as the water flows through subsurface materials; and

5) mixing relationships, if any, of these waters, and where mixing occurs.

The consistency and accuracy of chemical sampling plays a critical role and is discussed in Section 1.2.

1.1 Regulations

Under the Federal Water Pollution Control Act (1972 Amendments) no degradation of natural water quality is allowed. The Safe Drinking Water Act of 1974 authorizes the U.S. EPA to protect ground as well as surface water. Standards are set by states and must be approved by the U.S. EPA. In California, the State Water Resources Control Board sets such standards. The Lahontan Regional Water Quality Control Board, a state agency within the California State Water Resources Control Board, is the local agency responsible for enforcing the California Water Code (Porter-Cologne Act, adopted 1972 and amended) in the CGSA. Waste discharge permits must be applied for at least 120 days prior to commencement of discharge (Attachment 1A). Waste discharge and monitoring requirements will then be established for each particular discharge source, such as geothermal test or injection wells. Samples of such regulations for CGEH-1 test well and other geothermal operations in the Lahontan Region are presented in Attachments 1B and 1C.

The Geothermal Environmental Advisory Panel (GEAP, 1977) (Attachment 2) outlines water quality baseline data acquisition guidelines to be implemented by the USGS. The U.S. Energy Research and Development Administration (ERDA, 1977), (Attachment 3) discusses geothermal water quality monitoring programs applicable to Department of Energy (DOE) funded projects. Geothermal Resource Operational Order (GRO) No. 4 (ES Appendix A) defers water quality regulation to state and U.S. EPA requirements.

Table 1 lists the specific chemical parameters recommended for analysis by GEAP (1977), ERDA (1977) and this plan. The chemical analyses recommended in the GEAP (1977) and ERDA (1977) differ in the parameters they specify. To resolve these discrepancies and to take the individual environment at Coso into consideration, a synthesized set of analyses is suggested specifically for the CGSA. For example, boron, iron, and mercury have been added to the GEAP (1977) nongeothermal analysis list. Boron and iron were added due to their occurrence in the CGSA in some nonthermal waters at levels approaching or above safe limits. Mercury was added due to the mercury prospects in the Coso Mountains. Methane was dropped from the geothermal analysis since no methane is known to be dissolved in the geothermal fluid at Coso. However, it is beyond the scope of this monitoring plan to specify that the set

Table 1. Guidelines for Chemical Analyses of Geothermal and Nongeothermal Waters[a]

	ERDA (1977)	GEAP (1977)			Suggested for CGSA[b]	
	Geothermal	Geothermal	Surface	Ground	Geothermal	Nongeothermal
General Characteristics						
pH (lab)	x	x	x	x	x	x
TDS	x	x	x	x	x	x
Specific conductance (lab)		x	x	x	x	x
Suspended solids	x				x	
Turbidity	x				x	
Taste	x					
Odor	x				x	
Color	x					
Major Anions & Cations						
Alkalinity	x[c]	x	x	x	x[c]	x[c]
Chloride	x	x	x	x	x	x
Sulfate	x	x	x	x	x	x
Calcium	x	x	x	x	x	x
Sodium	x	x	x	x	x	x
Potassium	x	x	x	x	x	x
Magnesium	x	x	x	x	x	x
Gases						
Radon-222		x			x	
Hydrogen sulfide	x	x			x	
Carbon dioxide	x	x			x	
Methane	x					
Ammonia		x			x	
Sulphur dioxide		x			x	

Table 1 (continued)

	ERDA (1977)	GEAP (1977)			Suggested for CGSA[b]	
	Geothermal	Geothermal	Surface	Ground	Geothermal	Nongeothermal
Minor and Trace Constituents						
Arsenic	x	x			x	
Barium	x	x			x	
Boron	x	x			x	x
Bromide	x					
Cadmium		x			x[d]	
Cesium	x					
Copper	x	x			x	
Chromium		x			x[d]	
Fluoride	x	x	x	x	x	x
Iodide	x					
Iron	x	x			x	x
Lead	x	x			x	
Lithium	x				x	
Manganese	x	x			x	
Mercury	x	x			x	x
Molybdenum		x				
Rubidium	x					
Selenium		x			x[d]	
Silver	x	x			x	
Strontium		x				
Zinc	x	x			x	
Other						
BOD	x					
COD	x					
Nitrate			x	x		x
Ammonium	x	x			x	
Radioactivity (gross &)	x	x		x	x	x
Atmospheric reaction rate	x					
Evaporation rate	x					
Total phosphorus			x	x		x
Silica	x	x	x	x	x	x

Table 1 (continued)

	ERDA (1977)	GEAP (1977)			Suggested for CGSA[b]	
	Geothermal	Geothermal	Surface	Ground	Geothermal	Nongeothermal
Field						
pH		x	x	x	x	x
Specific conductance		x	x	x	x	x
Temperature		x	x	x	x	x
Discharge		x	x	x	x	x
DO	x	x	x	x	x	x
Sulfide					x	x[d]
Alkalinity					x	x

---

a These complete analyses are recommended only for the initial stages of baseline data acquisition. After the character of each water type is known less extensive continuing analyses may be employed. In some cases this may consist only of measurement of the "field" parameters if all indicators appear consistent with past measurements. However, complete analyses at selected critical locations should be repeated periodically during reservoir development and exploitation.

b These are suggestions only, not binding recommendations.

c Also reported as carbonate and bicarbonate.

d Optional analysis.

of analyses suggested for the CGSA shall supersede the ERDA (1977) or GEAP (1977) guidelines.

Table 2 lists inorganic chemical water standards for several typical uses specified by the U.S. EPA.

1.2 The Monitoring Plan

A consistently controlled and well documented baseline water chemistry survey of the CGSA should be conducted prior to development. Since accessible ground and surface water sources are limited (as shown on Plate 2.5-1) all should be sampled and analyzed according to accepted professional chemical sampling and analysis procedures. One complete survey, with analyses as specified in Table 1, should suffice to establish a baseline for well waters. Streams and springs should be sampled at high and low flows. Frequency of ongoing monitoring would depend on the location and extent of development.

Sample Collection and Chemical Analysis--

Sampling and analysis of waters and geothermal effluents is a specialized field. Some of the more relevant references are: Brown, et al. (1970); Wood (1976); Reed, (1975); Ellis, et al. (1968); Presser and Barnes (1974); U.S. EPA (1974, 1976b, 1978); American Public Health Association (1977); and Watson (1978). These works detail step-by-step procedures that should be

Table 2 Inorganic Chemical Water Standards

Substance	Drinking Water	Irrigating Water [a] (ppm) Threshold[e]	Irrigating Water [a] (ppm) Limiting[f]	Livestock Feeding Water[a] (ppm) Threshold[e]	Livestock Feeding Water[a] (ppm) Limiting[f]
Arsenic	0.05[b]	1.0	5.0	1	--
Barium	1.0[b]	--	--	--	--
Bicarbonate	--	--	--	500	500
Boron	--	--	0.5	--	--
Cadmium	0.01[c]	--	--	5	--
Calcium	--	--	--	500	1000
Chloride	250[c]	100	350	1500	3000
Chromium	0.05[b]	--	--	--	--
Copper	1.0[c]	0.1	1.0	--	--
Fluoride	1.4-2.4[b,d]	--	--	1	6
Hydrogen sulfide	0.5[c]	--	--	--	--
Iron	0.3[c]	--	--	--	--
Lead	0.05[b]	--	--	--	--
Magnesium	--	--	--	250	500
Manganese	0.05[c]	--	--	--	--
Mercury	0.002[b]	--	--	--	--
Nitrate	10[b]	--	--	200	400
Selenium	0.01[b]	--	--	--	--
Silver	0.05[b]	--	--	--	--
Sodium	--	--	--	1000	2000
Sulfate	250[c]	200	1000	500	1000
Zinc	5[c]	--	--	--	--
TDS	500[c]	500	1500	2500	5000
pH	6.5-8.5[c]	7.0-8.5	6.0-9.0	6.0-8.5	5.6-9.0

a Todd, 1970
b Maximum contaminant level specified in National Interim Primary Drinking Water Regulations (U.S. EPA, 1976)
c Maximum contaminant level specified in National Secondary Drinking Water Regulations (U.S. EPA, 1977)
d Maximum recommended concentration is temperature dependent
e Threshold--a concentration at which a given beneficial use is not damaged to any measurable degree
f Limiting--a concentration at which the beneficial use is severely inhibited

followed in collecting and analyzing water and geothermal effluent samples. The document by Watson (1978) is a standard methods manual specifically for sampling and analysis of geothermal fluids.

Sample collection procedures must be specified and consistently applied. These are fairly straightforward for most nongeothermal surface and ground water and are well outlined in several of the previously cited references. With geothermal fluids, a problem arises in collecting a representative sample. To obtain a representative sample from a superheated geothermal source, most investigators recommend collecting both liquid and vapor samples. Techniques used for such sampling are discussed in detail in Ellis, et al. (1968); Truesdale and Pering (1974); Giggenbach (1976); Hill and Morris (1975); U.S. EPA (1976b, 1978); Finlayson (1970); and Watson (1978).

In sampling hot springs, geysers, etc. use of a small hand or battery-operated pump with a long tube that can be inserted in the hot water is often convenient. This procedure will allow the sampler better access to the part of the manifestation that would provide the most appropriate sample.

For most of the historical data used in the baseline data acquisition it will be impossible to determine the sampling and analysis procedures used. Therefore, even though the data can be used in attempting to decipher temporal and spatial patterns, it would be desirable to start collecting baseline chemical data as soon as possible in a consistent, prescribed, reproducible manner. This would allow direct comparisons between consistent sets of chemical data collected before development begins and after development has commenced.

2.0 WATER LEVEL MONITORING

Water levels should be monitored for all accessible surface and ground water features (as shown on Plate 2.5-1) for a minimum period of one year prior to geothermal development. Water level measurements of the Coso Hot Springs are discussed separately in Section 3.

The historic natural variation in water levels in Little Lake would be difficult to determine since it is artifically filled during low water periods. In 1976 it was 3 feet lower than its present level (Hydrology Technical Report Section 2.1.1) Measurements of the water level in Little Lake may be made by installing a staff gauge in the lake and reading it periodically. This may be on the order of once a month until seasonal patterns are established. This monitoring should be coordinated with the owner of the lake to adjust artificial recharge into the lake or take that into account in analyzing the data.

Monitoring of ground water levels, including flow rates of springs, should initially be conducted at least four times a year to establish natural seasonal patterns prior to development. Long-term water level or spring flow rate fluctuations may not be determinable prior to development.

Aquifer tests should be conducted in wells to be used in conjunction with the geothermal operations to determine the safe perennial yield. Monitoring of water levels in these wells would be conducted frequently during the beginning of operations. When the water level stabilizes measurements may be taken less frequently. The pattern may start with measurements every week for several weeks, then each month for several months, then every three months for a year, then every 6 months for 2 years, then once a year.

Selected natural cool springs and wells that may be affected by lowering water levels in Rose Valley should be monitored regularly. These would include the spring or springs feeding Little Lake (e.g., 23S/38E-8DS1, 8DS2 and 8MS1, ES Plate 2.5-1), nearby wells (e.g., 23S/38E-8D1, 8D2, 5N1) as well as wells near ground water extraction areas.

3.0 COSO HOT SPRINGS

To determine if the hot springs would be disturbed by geothermal production, the baseline parameters must be quantified. There is considerable natural variation in the temperature, flow rate and chemical composition of the fluid at the springs. This range is a function of:

a) the source mechanism for the hot springs

b) the properties of hydraulic connection between the geothermal reservoir, shallow ground water and the hot springs, and

c) local climatic factors.

There are several possibilities for the source mechanism for the surface thermal manifestations at Coso Hot Springs. It is agreed that the "springs" are not in fact springs, but areas where steam condensate accumulates (Austin and Pringle, 1970). The working hypothesis model of the hot "spring" system is one where the top of the geothermal reservoir is essentially unconfined and boiling at about 150 feet beneath the surface thermal manifestations. The steam released from this boiling water table rises through fractures and mixes with local, shallow ground water. Portions of many fractures have become sealed by hydrothermal alteration of the rocks and/or deposition of silica. This sealing mechanism results in a circuitous path for the steam and limited surface manifestations above the reservoir.

The water level in the mud pots at the hot springs varies naturally with the seasons. They are higher in the winter and lower or almost dry in the summer. This variation is thought to be a function of varying mixture with shallow ground water, i.e. in the winter during periods of high rainfall more shallow ground water mixes with the steam condensate. (Austin and Pringle, 1970). The controlling mechanisms for mud pot water levels involve variations in steam condensate and shallow ground water contributions and variation of evaporation rates.

3.1 The Monitoring Plan

The properties of the springs must be quantified prior to development and monitored during development. A detailed water chemistry, temperature, evaporation, precipitation and water level analysis program at the hot springs is recommended for this purpose. Certain types of studies, such as diverting hot springs discharge to one flume, would be desirable but not permissible since the hot springs are a National Historic Site and no alteration of its natural state would be allowed. Studies and apparatus that we feel would cause negligible disturbance of the site and provide valuable clues to the spring mechanism include:

1. Continuous or frequent water temperature recording
2. Continuing operation of meteorological stations including precipitation, air temperature and wind measurements in the vicinity of the springs and in the Coso Range to the west
3. Pan evaporation measurements
4. Scale photographs of the mud pots (as required)
5. Continuous or frequent water level recording
6. Frequent water sampling and chemical analysis, including gas sampling and analysis (initially once or twice a month and then adjusted to a greater or lesser frequency as required)

7. Peak runoff gages on major ephemeral stream channels near the hot springs
8. Drilling a small observation well in the alluvium to the west of the surface manifestations
9. Drilling a data heat flow / water level and water chemistry hole in the alluvium to the east of the Coso Hot Springs fault

Items 1, 2, 3 and 4 will help define actual evaporation rates in the mud pots, thereby establishing quantity of inflow to the hot springs. Item 5 will define the water level changes. We may find that minute diurnal changes in mud pot temperatures or water level will provide clues to the hot spring mechanism. The water level data and size of the mud pots can provide an idea of the volumes of water in the pots at any given time. Item 6 will provide a detailed record of changes in chemistry with time. If shallow ground water does in fact contribute to the mud pots, a detailed series of chemical analyses should be able to establish that. Records from the peak runoff gauges, Item 7, would provide knowledge of when the precipitation exceeds the surface soil infiltration capacity. Item 8 would provide de facto evidence of the existence of a shallow ground water table in the alluvium to the west of the hot springs and a sample of such water for chemical analysis. Item 9 could provide information for several baseline tasks as well as help to better define the geothermal reservoir. For the hot springs monitoring it may indicate whether some contribution to the hot springs is possibly originating to the east of the

Hot Springs fault--perhaps from some depth and contributing to the hot springs effluent or to the geothermal reservoir itself. For water availability and quality, it would provide baseline water level and water chemistry characteristics in Coso Valley. For geothermal reservoir definition it would provide clues to the reason why the heat flow drops so sharply on the west side of Coso Valley.

The USGS is currently conducting an isotope study which is expected to provide valuable clues to the origin of geothermal and hot spring fluids, age of waters and source mechanisms. It is anticipated that the USGS will continue its isotope work where it is necessary, hence isotope studies are not discussed further. The NWC is currently monitoring the hot springs. A comparison of their monitoring program with the one proposed here is included as Attachment 4.

The results of the proposed studies, the USGS isotope study and the NWC monitoring will provide baseline hot springs characteristics and perhaps some insight into the connection between the hot springs and the geothermal reservoir.

4.0 GEOTHERMAL RESERVOIR

Monitoring of the geothermal reservoir will be conducted under the supervision of a geothermal reservoir engineer. Mass flow rate (or volume), temperature, pressure and chemical composition for each geothermal well will be monitored continuously or on a regular basis. The flow rate, wellhead pressure and annulus fluid pressure in all injection wells must be monitored continuously to provide the necessary data for reservoir management, well maintenance and pollution control. Chemistry of the injected fluid and annulus fluid should also be monitored regularly.

4.0.1 Injection Well Monitoring

Annulus fluid pressures and chemistry are monitored to detect leakage in the system. Depending on the composition of the fluid, adequate chemical monitoring may be accomplished by placing conductivity probes in the annulus, or by analyzing return flow for contamination in continuous cycling annulus fluid.

Corrosion rate can be determined by placing sample strips of the tubing and casing material in the well, and checking them periodically for weight loss.

Where injecting chemically active fluid, it is important that the well be shut down periodically for inspection and testing. Inspection methods for casing, tubing, cement and well bore include: (1) pulling the tubing and inspecting it visually or instrumentally; (2) electromagnetic caliper or televiewer logging of tubing or casing in the hole; (3) pressure testing of casing; (4) bond logging of casing cement; and (5) inspection of casing cement or well bore with injectivity or temperature profiles (Warner, 1975). Downhole geophysical methods are described in detail by Weiss, et al. (1979a).

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ATTACHMENT 1

SAMPLE WASTE DISCHARGE REQUIREMENTS AND MONITORING PLANS FOR GEOTHERMAL TEST WELLS ISSUED BY THE CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD - LAHONTAN REGION

A) REPORT OF WASTE DISCHARGE FORM

B) REGULATIONS AND MONITORING PLAN FOR CLEANOUT AND TESTING OF CGEH-1

C) REGULATIONS AND MONITORING PLANS FOR DISPOSAL OF GEOTHERMAL BRINES AND DRILLING WASTES FROM TWO GEOTHERMAL TEST WELLS IN LONG VALLEY

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

REPORT OF WASTE DISCHARGE
Pursuant to Division 7 of the State Water Code

FOR USE OF REGIONAL BOARD

WRCB Form 200 Rec'd: ________

Duty Fee: ________

Letter to Discharger: ________

Report Rec'd: ________

Effective Date: ________

(A) REPORT FROM:

Discharger ____________________
(Owner of Facility, Municipality, County, District, Firm or Individual)

Mailing Address ____________________ Zip Code

Telephone No. ____________

Name of Facility ____________________

(B) DESCRIPTION:

I. WASTE DISCHARGE: (check)
1. New discharge ---------- ( )
2. Existing discharge ---------- ( )
3. increase in quantity of discharge ---------- ( )
4. Change in character of waste ---------- ( )
5. Change in place or method of disposal ---------- ( )

II. LOCATION OF POINT OF DISPOSAL OR OPERATION (describe and attach map, sketch or locate on USGS Quadrangle map, 7.5 minute series.) List distances or bearing and distance from section corner or quarter corner, Section, Township, Range and Base and Meridian.)

____

____

III. WASTE TREATMENT OR DISPOSAL FACILITIES: (check)
1. Construction of entirely new facilities ---------- ( )
2. Enlargement of existing facilities ---------- ( )
3. Other (explain) ____________________

____

(C) TYPE OF WASTE DISCHARGE: (check)
1. Sewage only ---------- ( )
2. Industrial wastes only ---------- ( )
3. Mixed sewage and industrial wastes ---------- ( )
4. Solid wastes ---------- ( )

5. Cattle wastes ---------- ( )
6. Soil, silt, clay, etc. ---------- ( )

7. Other wastes ---------- ( )

(D) QUANTITY OF WASTES:
1. Present or proposed flow (in mgd) ____________
2. Design flow (in mgd) ____________
3. Present population ____________
4. Design population ____________
5. Solid waste disposal site (in cubic yards) ____________
6. Area in which soil will be disturbed (in acres) ____________

(E) SOURCE OF WATER SUPPLY:
1. Municipal or utility service ( )
2. Individual wells ( )
3. Surface supply: (a) Name of Stream ____________
(b) Type of Water Rights: Riparian ( ) Appropriation ( )
(c) Water Rights Permit or License Number ____________

(F) AMOUNT OF FILING FEES – (See attached Fee Schedule)
Amount of fee accompanying this report $ ____________

ALL OF THE STATEMENTS CONTAINED HEREIN ARE TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF AND ARE SUBMITTED UNDER PENALTY OF PERJURY.

SIGNATURE OF AUTHORIZED PERSON ____________________

Title ____________________
(Manager, Clerk, Engineer, Consultant, etc.)

Date ____________________

You will be notified of the correctness of filing fee and submittal of any additional information deemed necessary to complete your Report of Waste Discharge pursuant to Division 7, Section 13260 of the State Water Code.

WRCB Form 200(2–72)

(Rev. 6 - 5/15/72)

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION

FACT SHEET

ITEM NO. 4 BOARD ORDER NO. 6-78-37

NAME: China Lake Naval Weapons Center - Exploratory Geothermal Well

LOCATION: 8.0 miles (12.88 km) east of Coso Junction

TYPES OF WASTES: Geothermal groundwater and drilling fluids

TYPE OF OPERATION PRODUCING WASTES: The cleanout and testing of the geothermal exploratory well

TREATMENT: TYPE: None

DISCHARGE TO: A dry lake bed, unlined pond, and reinjection into the geothermal well

NEW CASE: Yes

RECEIVING WATERS: Groundwaters of the Coso Subunit of the Coso Hydrologic Unit

BENEFICIAL USES: Municipal and domestic supply

FISH, BIRDS OR ANIMALS, TYPES, DEGREE: Typical high desert habitat. Rodents, reptiles and non-game birds.

WATER QUALITY CONTROL PLAN OR LONG-RANGE POLICY: Contained in the Water Quality Control Plan for the South Lahontan Basin.

QUALITY OF RECEIVING WATERS: Geothermal groundwater underlies the proposed disposal site. The quality of this groundwater is unknown at this time.

QUANTITY OF WASTES: A maximum volume of 50 acre ft. (61 megaliters) will be discharged.

DISCHARGE ON LAND OWNED BY: Department of the Navy

CONTROLLED BY: Department of the Navy

NEAREST HOME, OTHER BUILDING AND TYPE: Distant

NEAREST WATERWELL: Distant

NATURE OF AREA: High desert, mountainous

QUALITY OF WASTES: Quality of the geothermal groundwater that will be discharged to the disposal site is not known.

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION

BOARD ORDER NO. 6-78-37

WASTE DISCHARGE REQUIREMENTS
FOR

DEPARTMENT OF THE NAVY
CHINA LAKE NAVAL WEAPONS CENTER
EXPLORATORY GEOTHERMAL WELL
Inyo County

The California Regional Water Quality Control Board, Lahontan Region, finds:

1. Captain R.B. Wilson on behalf of the China Lake Naval Weapons Center, Department of the Navy, submitted the information necessary to make up a report of waste discharge dated November 22, 1977 for an existing exploratory geothermal well.

2. The Department of the Navy plans to dispose of a maximum of 50 acre feet (61 megaliters) of wastewater that will be generated by the cleanout and testing of an existing exploratory geothermal well. The wastewater will consist of geothermal groundwater and drilling fluids remaining in the well. Chemical analyses to determine the quality of the geothermal groundwater have been postponed until after the cleanout operation has been completed.

3. The Department of the Navy plans to discharge the wastewater pumped from the geothermal well to a proposed unlined pond. The capacity of this pond may not be able to handle the entire amount of wastewater that will need to be pumped from the well. If this occurs, a nearby small dry lake bed will be utilized as a disposal site. If the wastewater is found to be toxic to animal life, it will be contained temporarily on-site in the pond and then reinjected back into the geothermal well.

4. The dry lake bed, existing geothermal well and the proposed pond are located approximately 8.0 miles (12.88 km) east of Coso Junction, as shown on Attachment "A" which is made a part of this order. The lake bed, geothermal well, and pond are the only designated disposal sites.

5. The disposal facilities are located in the Coso Subunit of the Coso Hydrologic Unit within the NE/4, Section 6 and the NW/4, Section 5, T22S, R39E, MDB&M.

6. The disposal facilities are located in a shallow closed basin in soils consisting of pumice with scattered lenses of clay. Due to the lack of fresh groundwater underlying the disposal sites and the reported geological conditions underlying the area, it appears that the wastewater may be discharged to unlined ponds and a dry lake bed without creating a threat to groundwater quality in the area.

7. The designated disposal sites are located on land owned by the U. S. Government, Department of the Navy.

8. The Board adopted the Water Quality Control Plan for the South Lahontan Basin on May 8, 1975.

9. The potential beneficial uses of the groundwaters of the Coso Subunit of the Coso Hydrologic Unit as set forth and defined in the plan are:

   a. municipal and domestic supply

10. The Board has notified the discharger and interested agencies and persons of its intent to prescribe waste discharge requirements for this discharge.

11. The U. S. Department of Energy has prepared an environmental analysis and has concluded that mitigation measures presently exist which address the impacts of the project and that an Environmental Impact Statement is not necessary. The Department of Energy has therefore adopted the equivalent of a negative declaration in accordance with the California Environmental Quality Act.

12. The Board, in a public meeting, heard and considered all comments pertaining to the discharge.

IT IS HEREBY ORDERED, that the U. S. Department of the Navy, China Lake Naval Weapons Center shall comply with the following:

A. DISCHARGE SPECIFICATIONS

   1. The total volume of wastewater discharged to the disposal facilities shall not exceed 50 acre feet (61 megaliters).

   2. The discharge of wastewater except to the designated disposal sites is prohibited.

   3. Wastewater shall not be injected into any groundwater containing a total dissolved solids content which is less than that of the wastewater being discharged.

4. The waste discharge shall not result in any perceptible color, odor, taste or foaming in surface or ground waters of the Coso Subunit of the Coso Hydrologic Unit.

5. Surface flow or visible discharge of wastewater from the designated disposal sites to adjacent land areas or surface waters is prohibited.

6. All facilities used for collection, transport, treatment or disposal of waste shall be adequately protected against overflow, washout or inundation from a storm or flood having a recurrence interval of once in 100 years.

7. The vertical distance between the water surface elevation and the lowest point of a pond dike or the invert of an overflow structure shall not be less than 1.5 feet (0.46 m).

8. The discharge shall not cause a pollution.

9. Neither the treatment nor the discharge shall cause a nuisance.

B. PROVISIONS

1. Wastes left on-site may be required to be transported to an approved solid waste disposal site in the area if such a site is established sometime in the future.

2. At least 30 days in advance of the cessation of discharge at the site, the discharger shall send a report to the Regional Board that accurately describes the exact location of any wastes remaining at the site, with surveyed references from a monument of known location.

3. Adequate protective works and maintenance shall be provided to assure that ponds will not become eroded or otherwise damaged.

4. A sample of the geothermal groundwater shall be collected after the geothermal well cleanout operation has been completed. A complete chemical analyses shall be conducted on this sample. Further discharge of wastewater after the cleanout operation shall not occur until the Executive Officer has reviewed the chemical analyses and approved the continuation of the discharge.

5. Contingency plans shall be established and shall contain plans for implementing the immediate termination of a wastewater discharge resulting from an equipment failure. Contingency plans shall be submitted to the Regional Board at least 30 days in advance of initiating a discharge at the site.

6. The discharger shall comply with Monitoring and Reporting Program No. 78-37 and with the "General Provisions for Monitoring and Reporting" as specified by the Executive Officer.

7. The discharger shall immediately notify the Regional Board by telephone whenever an adverse condition occurs as a result of this discharge; written confirmation shall follow.

8. Any proposed material change in the character of the waste, manner or method of treatment or disposal, increase of discharge, or location of discharge shall be reported to this Regional Board at least ninety (90) days in advance of implementation of any such proposal.

9. The California Regional Water Quality Control Board, Lahontan Region, hereby reserves the privilege of changing all or any portion of this order upon legal notice to and after opportunity to be heard is given to all concerned parties.

10. The owner of property subject to waste discharge requirements shall be considered to have a continuing responsibility for ensuring compliance with applicable waste discharge requirements in the operation or use of the owned property. Any change in the ownership and/or operation of property subject to waste discharge requirements shall be reported to this Regional Board. Notification of applicable waste discharge requirements shall be furnished the new owner(s) and/or operator(s). A copy of such notification shall be sent to this Regional Board.

I, Roy C. Hampson, Executive Officer, do hereby certify that the foregoing is a full, true and correct copy of an order adopted by the California Regional Water Quality Control Board, Lahontan Region, on June 8, 1978.

Roy C. Hampson

ROY C. HAMPSON
EXECUTIVE OFFICER

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION

MONITORING AND REPORTING PROGRAM NO. 78-37
FOR

DEPARTMENT OF THE NAVY
CHINA LAKE NAVAL WEAPONS CENTER
EXPLORATORY GEOTHERMAL WELL
Inyo County

MONITORING

When a discharge to a location other than the designated disposal sites occurs, the following shall be included in a detailed technical report:

1. When the discharge occurred
2. Volume of wastewater discharged
3. Why the discharge occurred
4. A description of the total area that the discharge came in contact with
5. A plan of action for preventing further discharges and a timetable for implementing this plan of action

The following shall be recorded monthly:

1. The volume of wastes discharged during the reporting period
2. The total volume of wastes contained in the ponds and the dry lake bed disposal area
3. The total filterable residue (in mg/l) of the water contained at each disposal site

At least 30 days prior to the cessation of the operation of the test well, a special report shall be submitted to the Regional Board outlining the procedures for closing down the site and a time schedule for their implementation. This report shall include at least the following:

1. Map showing the exact well location and its relative location to all onsite disposal locations
2. The legal point of disposal for any materials to be deposited offsite

3. The name and license number of any liquid waste hauler handling waste materials from this operation
4. A description of the sealing procedures to be used for all facilities at this site.

Quarterly monitoring reports including the preceding information shall be submitted to the Regional Board by the 15th day following each quarterly reporting period. The first report will be due July 15, 1978.

Ordered by: ______________________ Dated: June 12, 1978
ROY C. HAMPSON
EXECUTIVE OFFICER

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION

FACT SHEET

ITEM NO. 8 BOARD ORDER NO. 6-77-122

NAME: Union Oil Company of California

LOCATION:: 6½ and 9 miles northeast of Mammoth Lakes, in Long Valley, Mono County

TYPE OF WASTES: Geothermal brines, drilling wastes and drilling mud

TYPE OF OPERATIONS PRODUCING WASTES: Two Geothermal Test Wells

TREATMENT: TYPE: None - wastes confined to lined evaporation ponds CAPACITY: 0.5 million gallons (1.9 megaliters)

DISCHARGE TO: Clay-lined evaporation ponds

NEW CASE: Yes

RECEIVING WATERS: Groundwaters and surface waters of the Upper Owens Subunit of the Owens Hydrologic Unit

BENEFICIAL USES OF GROUNDWATERS: Municipal and domestic supply; agricultural supply; industrial service; freshwater replenishment

BENEFICIAL USES OF SURFACEWATERS: Agricultural supply; industrial and municipal supply; water-contact recreation; noncontact-water recreation; wildlife habitat; cold freshwater habitat; groundwater recharge.

FISH, BIRDS OR ANIMALS, TYPES, DEGREE: Coniferous forest located in high desert, Sierra-Nevada transition zone. Forest and sagebrush communities include small rodents, sage hen and deer.

WATER QUALITY CONTROL PLAN OR LONG-RANGE POLICY: Contained in the Water Quality Control Plan for the South Lahontan Basin

QUALITY OF RECEIVING WATERS: Excellent for all beneficial uses

QUANTITY OF WASTES: Not to exceed 0.5 million gallons (1.9 megaliters) at each site

DISCHARGE ON LAND OWNED BY: R. A. Cashbaugh, Et Al, and Standard Industrial Minerals, Inc.

CONTROLLED BY: Union Oil Company of California

NEAREST HOME, OTHER BUILDING & TYPE: Cashbaugh site; One dwelling is about 1,000 feet north
Clay Pit site; no structures nearby

NEAREST WATER WELL: Not known

NATURE OF AREA: Range land transition to coniferous forest

QUALITY OF WASTES: High in dissolved solids and high pH

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION

BOARD ORDER NO. 6-77-122
FOR

UNION OIL COMPANY OF CALIFORNIA
CASHBAUGH RANCH AND CLAY PIT GEOTHERMAL TEST WELLS
Mono County

The California Regional Water Quality Control Board, Lahontan Region, finds:

1. Mr. Vane R. Suter, on behalf of the Union Oil Company of California, Geothermal Division, submitted a complete report of waste discharge dated August 12, 1977 for two proposed geothermal test wells.

2. The Union Oil Company of California, Geothermal Division, is proposing to drill two deep test wells in the Long Valley Area at the sites shown on Attachment "A" which is made a part of this Order. The Cashbaugh Ranch Well Site is approximately four miles (6.4 km) northeast of Highway 395 and the Mammoth Airport in the SE/4, Section 18, T3S, R29E, MDB&M. The Clay Pit Well Site is located approximately five miles (8 km) east of Highway 395 in Little Antelope Valley, in the NE/4, Section 15, T3S, R28E, MDB&M.

3. The proposed drilling site for the Cashbaugh Well is located on land owned by R.A. Cashbaugh, et al. The proposed drilling site for the Clay Pit Well is located on land owned by Standard Industrial Minerals, Inc. Both sites are leased by the Union Oil Company, Geothermal Division.

4. Wastes produced from the drilling and testing of the proposed wells include drilling cuttings, drilling mud, water, cement, and geothermal brines. It is estimated that less than 0.5 million gallons (1.9 mega liters) total of waste material will be discharged to each evaporation pond. The designated discharge sites for the drilling wastes, mud, and fluids from the well operations will be clay-lined evaporation ponds adjacent to the wells. Wastes from either of the wells may be discharged to either of the evaporation pond sites.

5. Both proposed test well sites are located in the Long Hydrologic Subunit of the Owens Hydrologic Unit. The Cashbaugh Ranch Well Site is located in a small sand and gravel pit surrounded by sagebrush covered terrain. Hot Creek is located approximately 1,000 feet (305 m) from the drilling site. The Clay Pit Well Site is located within a commercial open pit clay mine surrounded by forested terrain. There are no surface waters adjacent to the site.

6. The beneficial uses of the groundwaters of the Long Subunit of the Owens Hydrologic Unit as set forth and defined in the Plan are:

   a. municipal and domestic supply
   b. agricultural supply
   c. industrial service
   d. freshwater replenishment

7. The beneficial uses of the waters of Hot Creek as set forth and defined in the Plan are:

   a. agricultural supply
   b. industrial service
   c. water-contact recreation
   d. non-water-contact recreation
   e. wildlife habitat
   f. cold freshwater habitat
   g. groundwater recharge

8. The Board has notified the discharger and interested agencies and persons of its intent to adopt waste discharge requirements for this discharge.

9. The County of Mono has prepared a negative declaration in accordance with the California Environmental Quality Act (Public Resources Code Section 21000 et seq.) and the State Guidelines.

10. The Regional Board has reviewed the negative declaration and determined there will be no substantial adverse changes in the environment as a result of the project.

11. The Board, in a public meeting, heard and considered all comments pertaining to the discharge.

IT IS HEREBY ORDERED, the Union Oil Company of California shall comply with the following:

A. DISCHARGE SPECIFICATIONS

1. Any above-ground discharge and/or storage of wastewater except in ponds effectively sealed[a] to prevent the exfiltration of wastes is prohibited.

2. The discharge of wastes except to the designated disposal site is prohibited.

a/ Effectively sealed in this case is equivalent to a 1.5 foot (0.46 m) thick clay-liner having a permeability of 1×10^{-3} cm/sec or less for the Cashbaugh Ranch Well site and a 1.0 foot (.31 m) thick clay-liner having a permeability of 1×10^{-6} cm/sec or less for the Clay Pit Well site.

3. There shall be no surface flow or visible discharge of wastewater from the designated disposal sites to adjacent land areas or surface waters.

4. Wastewater that is not discharged to the designated disposal sites due to equipment failure shall be collected and contained to prevent contact with other surface waters and to prevent percolation to useable groundwaters.

5. All facilities used for storage, transport, treatment or disposal of waste shall be adequately protected against overflow, washout or inundation from a storm or flood having a recurrence interval of once in 100 years.

6. During the period that liquids are contained in the wastewater ponds, a minimum freeboard of at least 1.5 feet (0.5 m) shall be maintained.

7. The liquid portion of all brines shall be removed from the pond 90 days after the operation ceases.

8. All pond and/or drilling materials not hauled to a legal point of disposal shall be located within the evaporation pond and covered by a minimum of two feet (0.6 m) of material having a permeability of less than 10^{-6} cm/sec. The cover materials shall be placed to promote runoff of any onsite precipitation.

9. The waste discharge shall not result in any perceptible color, odor, taste or foaming in surface or ground waters of the Owens Hydrologic Unit.

10. The discharge shall not cause a pollution.

11. Neither the treatment nor the discharge shall cause a nuisance.

B. PROVISIONS

1. Contingency plans shall be established and shall contain plans for implementing the immediate termination of a wastewater discharge resulting from an equipment failure. Contingency plans shall be submitted to the Regional Board at least 30 days prior to the initiation of work at the sites and must be approved by the Executive Officer before work begins.

2. Wastes left onsite may be required to be transported to an approved solid waste disposal site in the area if such a site is established sometime in the future.

3. At least 30 days in advance of completion of work at the site, the discharger shall send a report to the Regional Board that accurately describes the exact location of any wastes remaining at the site, with surveyed references from a monument of known location.

4. Adequate protective works and maintenance shall be provided to assure that the ponds will not become eroded or otherwise damaged.

5. The discharger shall immediately notify the Regional Board by telephone when drilling has begun and whenever an adverse condition occurs as a result of this work; written confirmation shall follow.

6. Prior to the discharge of any geothermal materials into the ponds, the discharger shall submit a certificate, signed by a Civil Engineer registered in the State of California, stating that the ponds and attendant facilities comply with the requirements of this Order.

7. The discharger shall comply with the Monitoring and Reporting Program No.77-122 and with the "General Provisions for Monitoring and Reporting" as specified by the Executive Officer.

8. Any proposed material change in the character of the waste, method of disposal, increase of discharge, or location of discharge, shall be reported to this Regional Board at least ninety (90) days in advance of implementation of any such proposal.

9. Surface waters, as used in this Order, include, but are not limited to, live streams, either perennial or ephemeral, which flow in natural or artificial watercourses and natural lakes and artificial impoundments of waters within the State of California.

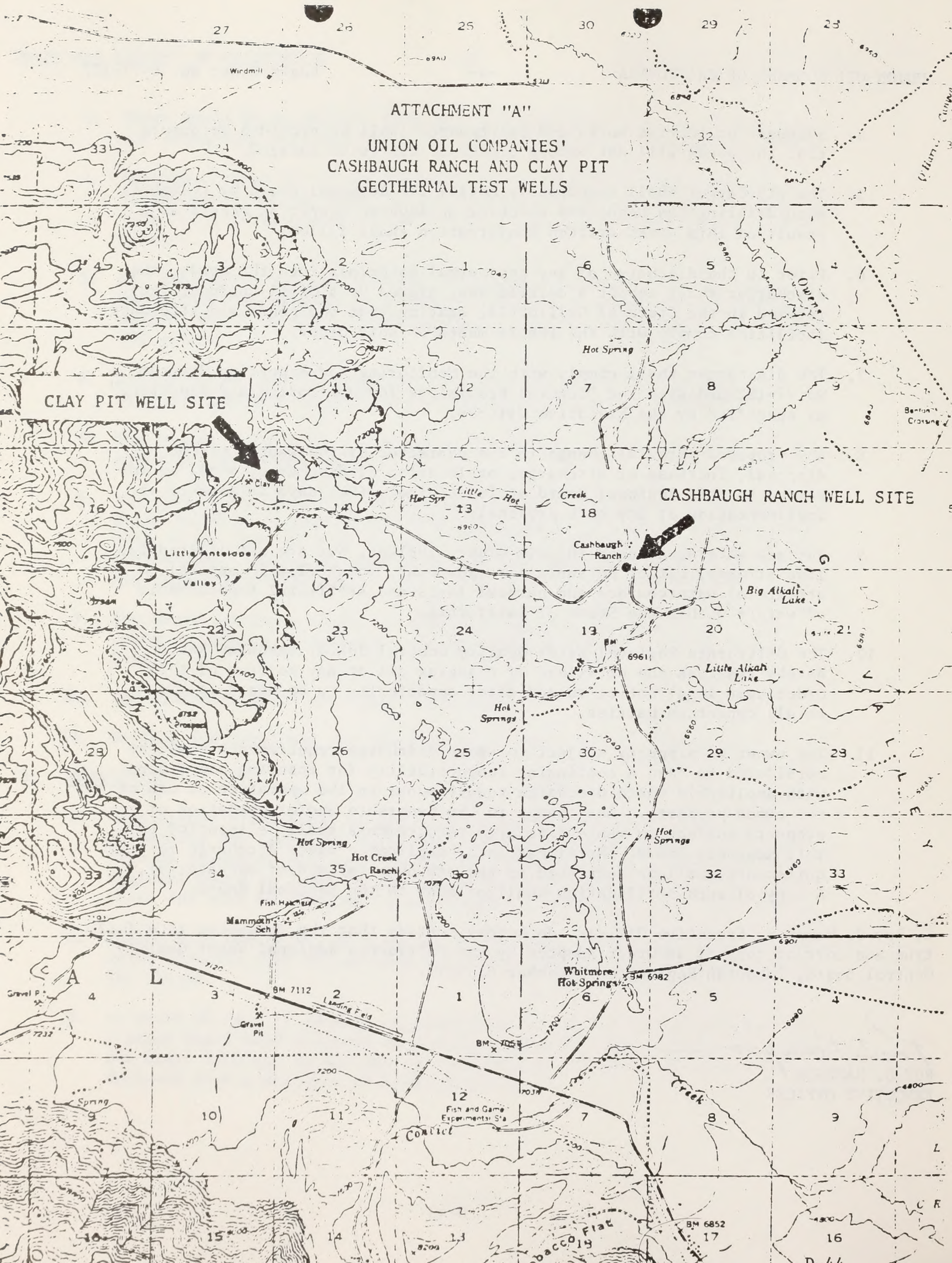
10. The California Regional Water Quality Control Board, Lahontan Region, hereby reserves the privilege of changing all or any portion of this Order upon legal notice to and after opportunity to be heard is given to all concerned parties.

11. The owner of property subject to waste discharge requirements shall be considered to have a continuing responsibility for ensuring compliance with applicable waste discharge requirements in the operation or use of the owned property. Any change in the ownership and/or operation of property subject to waste discharge requirements shall be reported to this Regional Board. Notification of applicable waste discharge requirements shall be furnished to the new owner(s) and/or operator(s). A copy of such notification shall be sent to the Regional Board.

I, Roy C. Hampson, Executive Officer, do hereby certify that the foregoing is a full, true and correct copy of an Order adopted by the California Regional Water Quality Control Board, Lahontan Region, on December 8, 1977.

Roy C. Hampson

ROY C. HAMPSON
EXECUTIVE OFFICER


ATTACHMENT "A"
UNION OIL COMPANIES'
CASHBAUGH RANCH AND CLAY PIT
GEOTHERMAL TEST WELLS
CLAY PIT WELL SITE
CASHBAUGH RANCH WELL SITE
Windmill
Clay Pit
Little Antelope Valley
Hot Spring
Little Hot Creek
Cashbaugh Ranch
Big Alkali Lake
Little Alkali Lake
Hot Springs
Benton Crossing
Prospect
Hot Creek Ranch
Mammoth Sch
Whitmore Hot Springs
Landing Field
Gravel Pit
Fish and Game Experimental Sta
Tobacco Flat

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION

MONITORING AND REPORTING PROGRAM NO. 77-122
FOR

UNION OIL COMPANY OF CALIFORNIA
CASHBAUGH RANCH AND CLAY PIT GEOTHERMAL TEST WELLS
Mono County

MONITORING

When a discharge to a location other than the designated disposal sites occurs, the following shall be included in a detailed technical report:

1. When the discharge occurred.
2. Volume of wastewater discharged.
3. Why the discharge occurred.
4. A description of the total area that the discharge came in contact with.
5. A plan of action for preventing further discharges and a timetable for implementing this plan of action.

The following shall be recorded monthly:

1. The volume of wastes discharged during the reporting period.
2. The total volume of wastes contained in the ponds.
3. The total filterable residue (in mg/l) of the water contained in each pond.

At least 30 days prior to the cessation of the operation of any test well, a special report shall be submitted to the Regional Board outlining the procedures for closing down the site and a time schedule for their implementation. This report shall include at least the following:

1. Map showing the exact well location and its relative location to all onsite disposal locations.
2. The legal point of disposal for any materials to be deposited offsite.
3. The name and license number of any liquid waste hauler handling waste materials from this operation.
4. A description of the sealing procedures to be used for all facilities at this site.

REPORTING

A technical report shall be submitted immediately after a discharge occurs at a location other than the designated disposal site.

Information recorded monthly shall be submitted quarterly to the Regional Board by the 15th day of the following month. The first monitoring report is due January 15, 1978.

ORDERED BY: Roy C. Hampson DATED: December 15, 1977
ROY C. HAMPSON
EXECUTIVE OFFICER

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION

TRANSMITTAL OF COMMENTS AND RECOMMENDATIONS OF OTHER
GOVERNMENTAL AGENCIES
FOR

UNION OIL COMPANY OF CALIFORNIA
CASHBAUGH RANCH AND CLAY PIT
GEOTHERMAL TEST WELLS
Mono County

Other governmental agencies have requested the inclusion of the following additional requirements and recommendations which are not directly related to water quality:

STATE DEPARTMENT OF HEALTH, VECTOR AND WASTE MANAGEMENT SECTION

The discharger should be advised that he will be required to comply with the health-related minimum standards for solid waste handling and disposal as set forth in Section 17200 et seq., Title 14, and this Department's hazardous waste regulations, Sections 60100 et seq., Title 22, California Administrative Code. Compliance with those standards and with the proposed waste discharge requirements should protect the public health, domestic livestock and wildlife.

ATTACHMENT 2

WATER QUALITY BASELINE DATA ACQUISITION GUIDELINES
(SECTION 4.0 FROM
GEOTHERMAL ENVIRONMENTAL ADVISORY PANEL,
1977, pp. 13-17)

4.0 WATER QUALITY

4.1 Introduction

Procedures recommended for establishing a water-quality baseline on geothermal leases and units are divided into two categories, 1) general, and 2) site specific. These recommendations stem from the principle that detailed knowledge of water quality in the environment and of the geothermal fluid(s) is needed early in any operation, to establish baseline concentrations and to determine which potentially harmful constituents are present. Later, measurements may be limited to those constituents that may adversely affect the environment.

4.2 General sampling requirements

To provide an adequate body of baseline data on water quality, the following procedures and principles are generally recommended for all leases or units:

4.21 Standards

Collection and analysis of water samples should be done according to current methods published by EPA, USGS, "Standard Methods" as summarized in "Recommended Methods for Water-Data Acquisition" (3). Analyses by State-certified laboratories are preferred.

4.22 Sources to be sampled

A. Surface water

Where present, perennial streams and significant intermittent streams should be sampled at or near the upstream and downstream boundaries of the lease or unit. Ponds, lakes, canals and drains, if present, should also be sampled. In areas of complex ownership or development lessees should be encouraged to develop sampling programs on a cooperative basis (1.4 above) taking into consideration differences in topography, geology, land use and access.

B. Ground water

Where present, ground-water sources (springs, seeps, and water wells) on the leasehold should be sampled for analysis as prescribed by the Supervisor. If the leasehold overlies and is upgradient from parts of an aquifer from which water is used for domestic, irrigation, stock, or wildlife supply, the Supervisor may require the lessee to obtain water samples for analysis from that aquifer during the drilling of geothermal wells, even though no wells on the lease hold produce from that aquifer.

C. Geothermal fluids

Geothermal fluids produced under the lease should be sampled for analysis according to provisions of GRO Order No. 4, and as specified below. (see 4.31).

4.23 Frequency and duration of sampling

A. The Supervisor should have wide latitude in determining frequency and duration of sampling during the baseline period.

B. The size, nature, intensity of development, and use of the geothermal resources should be important determining factors.

C. Frequency of sampling of streams should be selected with regard to the regimen and environment of the stream. Quarterly samples may define basic conditions in areas where streamflow is fairly uniform. In areas of significant seasonal variation, times of sampling should be adjusted to determine quality of typical high and low flows and/or of extreme events.

D. Ground-water sources upgradient of lessee's structures should be sampled at least once. Downgradient sources should be sampled at frequencies determined by the Supervisor in light of the chemical quality of geothermal fluids and other conditions and events peculiar to the lease.

E. Natural discharges of geothermal fluids (as from hot springs) should be sampled at least once prior to commencement of exploration drilling, and at least once more during the baseline data period.

F. Artificially produced geothermal fluids should be sampled for analysis when encountered and after there has been enough discharge to assure that the sample is representative of fluid(s) in the producing zone. Thereafter, samples may be required by the Supervisor after any major modification to the well or change in flow characteristics.

4.24 Parameters to be measured

A. Physical

1. Discharge of streams, wells, and springs should be measured each time a sample is taken.

2. Temperature should be determined each time a water source is sampled. Precision should be:

$0.2^{o}C$ in the range 0^{o} to $30^{o}C$
$1.0^{o}C$ in the range 31^{o} to $100^{o}C$
5.0^{o} above $100^{o}C$

3. pH should be determined each time a water source is sampled. For the range 6.0 to 9.0 a precision of about 0.5 pH unit will be accepted. Outside of this range more precise measurements should be obtained.

4. Specific conductance should be determined each time a water source is sampled.

5. Turbidity should be measured on surface-water samples where eutrophication exists or is threatened.

B. Chemical

1. Surface waters

The first surface water sample from each site should receive a standard analysis. Standard analyses include DO, SiO_2, Ca, Mg, Na, K, alkalinity, SO_4, Cl, NO_3, F, dissolved solids, total P. Thereafter, where specific conductance does not increase by more than 10 percent, repeat analyses may not be required.

2. Ground water

Ground-water samples from each sampling site should be given standard analysis as required for surface water at least once. Analysis of the first sample from each ground-water source shall include an assay for gross radioactivity.

4.3 Site Specific sampling requirements

The following requirements are to be within the province of the Supervisor and should become part of the required environmental baseline for surface and ground waters when toxic substances have been determined to exist in natural discharges of geothermal fluids or in fluids from geothermal wells, or if the Supervisor has reason to expect that toxic substances exist owing to geologic or other conditions. If the lessee in his plan of operation indicates he intends to use toxic substances, a baseline for such substances should be established prior to their introduction on the lease.

4.31 Geothermal fluids

A. All pre-lease thermal wells and hot springs should be sampled in accordance with 4.23 E above. In addition to the standard analysis the following components are to be quantified by accepted laboratory methods (reference 4)

1. Gases: CO_2, H_2S, SO_2, NH_3, and Rn-222

2. Water: As, Ag, B, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Mo, NH_4, Pb, Se, Sr, and Zn.

B. Analysis of produced geothermal fluids is required under provisions of GRO Order No. 4, section 10, within 30 days of completion of any geothermal well.

C. Analyses of geothermal fluids should include determination of gross radioactivity. If radioactivity exceeds the following values (gross α > 10 pCi/ℓ, gross β > 50 pCi/ℓ) the Supervisor may require specific radionuclide assays of these and other water sources on the lease.

4.32 If water pollution is threatened from sources on the lease other than geothermal fluids the Supervisor should require sampling and analysis of those sources and of the water bodies (surface or subsurface) threatened. Potential sources of pollution include, but are not restricted to, effluent or drainage streams including road culverts, mud pits or other sumps, sanitary facilities, and waste-disposal leachates.

4.33 Biochemical, bacteriological, and organic quality of streams, canals and drains should be determined at the discretion of the Supervisor. In general, stations upstream and downstream from construction sites will be of principal interest. Parameters that may be called for include: BOD_5, TOC, COD, fecal coliform bacteria, and fecal streptococcus bacteria. Pesticide analysis should be required if pesticides have been used extensively on the leasehold.

Leachates of any origin originating on the leasehold should be analyzed for deleterious organic constituents and characteristics.

The Supervisor may require biochemical, bacteriological, and organic quality determinations on runoff from construction sites such as roads and drilling pads if that runoff reaches a body of surface water.

4.34 Samples for determination of suspended sediment may be taken from surface sources at discretion of the Supervisor. The load of any component absorbed on suspended sediment may require quantification.

4.35 Standing surface-water bodies (such as ponds, lakes, or reservoirs) on the leasehold or within the realm of influence from operations on the leasehold should be sampled for analysis to determine water quality prior to operations by the lessee. Dissolved oxygen, BOD_5, pH, specific conductance, temperature, and fecal bacteria may be determined monthly or seasonally.

ATTACHMENT 3

SURFACE AND GROUND WATER SECTIONS
FROM SECTION 5. EFFLUENT AND
ENVIRONMENTAL MEASUREMENT AND
MONITORING PROGRAMS
(ERDA, 1977, pp. 34-37)

5. EFFLUENT AND ENVIRONMENTAL MEASUREMENT AND MONITORING PROGRAMS

In this chapter the user should describe the procedures for collection of the baseline data presented in other chapters and discuss any plans or programs for environmental monitoring to detect impacts of the proposed activity.

This chapter is not required for those activities that belong to the Systems Development or Exploration categories; it is optional for activities classified as Production Testing (see Table 2 in Part A). However, if there are measurement or monitoring programs for a proposed activity from one of these categories, the user is encouraged to report them. Environmental reports for all other activities should contain a description of relevant measurement and monitoring programs. In each case the user should supply information only to the extent that it is pertinent to environmental characterization and environmental effects described in Chapters 3 and 4.

5.1 PROGRAM UNDERTAKEN PRIOR TO THE START OF THE PROPOSED ACTIVITY

This section should describe the program for characterizing the site and the surrounding region (including any rights-of-way related to the project) prior to the start of the proposed activity. The guide indicates general environmental factors to be evaluated and the parameters to be measured; the user should add any other factors necessary to provide reasonably complete baseline data against which to measure future impacts. Excellent guidance for developing an environmental measurements program is given in "Guidelines for Acquiring Environmental Baseline Data on Federal Geothermal Leases" (The Geothermal Environmental Advisory Panel, January 1977).*

The program for collection of initial or baseline environmental data prior to initiating the proposed activity should be described in sufficient detail to demonstrate that the user has established a thorough and comprehensive approach to data collection. The description of the program should be confined principally to technical descriptions of instrumentation, scheduling, technique and procedures.

Particular attention should be paid to the description of sampling design, sampling frequency, statistical methodology and validity (including calibration checks and standards) in order to justify the scope of the program and the timing and scheduling of data collection. Information should be provided on instrument accuracy, sensitivity and reliability. When standard analytical or sampling techniques are to be utilized, they need only be identified and referenced.

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*Copies may be obtained from the Chairman, Geothermal Environmental Advisory Panel, 345 Middlefield Road, Menlo Park, CA 94025.

When information from the literature has been used, it should be concisely summarized and documented by reference to original data sources. When the availability of original sources that support important conclusions is limited, either extensive quotations or references to secondary sources should be provided. In all cases, information derived from published results should be clearly distinguished from information derived from the user's field measurements.

5.1.1 Surface Waters

When a body of surface water may be affected by the proposed activity, the report should describe the means by which the baseline conditions of the water and the related ecology were determined. Sufficient data should be gathered to permit verification of any predictive computations or models used in the evaluation of environmental effects.

The methods for measuring physical and chemical parameters of surface waters should be described. The user's sampling program should be outlined in sufficient detail to demonstrate its adequacy with respect to both spatial coverage (i.e., surface area and depth) and temporal coverage (i.e., duration and sampling frequency), giving due consideration to seasonal effects. The techniques used to investigate any condition that might lead to interactions with effluents (such as how the presence of impurities in a water body may react synergistically with heated effluent or how the heated effluent may restrict mixing and dispersion of pollutants) should be described.

Table 5 lists the important chemical species occasionally found in spent geothermal fluids. The physical properties of water likely to be affected by any geothermal effluent discharges are also listed. The monitoring program need not include all of these parameters but should cover those that are expected to significantly impair the quality of surface waters. Other important parameters not listed should be reported if unusual ambient conditions warrant their inclusion.

The report should describe any computational models used in predicting spatial and temporal changes in surface water quality and the dispersion characteristics of surface waters. The discussion should include the bases for these models, the means for their verification, and their validity and accuracy.

The user should describe the baseline program used to characterize aquatic systems in the project area. Details concerning the rationale, techniques, and equipment used for ecological assessments should be included. All sampling programs should be discussed in terms of the pattern and frequency of sampling and duration of observations, with emphasis on those procedures used to establish the presence and abundance of important species.

The methods of analysis and interpretations of field and laboratory data should be discussed. This discussion should include degrees of precision and accuracy of reported estimates when appropriate. Procedures for verification of taxonomic determinations should be discussed, either by reference to a collection of voucher specimens or other means whereby consistent identification of species is assured.

Table 5. Water Quality Parameters Associated With Geothermal Effluents

Chemical Parameters		
Ag	F	NH_4^+
As	Fe	Pb
B as H_3BO_3	HCO_3^-	Rb
Ba	Hg	Si as SiO_2
Br	H_2S	$SO_4^=$
Ca	I	Zn
CH_4	K	Alkalinity, acidity and pH
Cl	Li	Total dissolved solids
CO_2	Mg	Dissolved oxygen
Cs	Mn	BOD and COD
Cu	Na	Radioactivity

Physical Parameters

Color

Suspended solids

Taste and odor

Temperature

Turbidity

Atmospheric reaeration rate

Evaporation rate

Velocity (average)

Rationale for predictions of any nonlethal physiological or behavioral responses of important species due to project-related impacts should be discussed. Parameters of stress for important species of the aquatic systems should be identified, including potential synergistic effects.

5.1.2 Groundwater

The monitoring program for detection of impacts on local groundwater should be described.

Required information concerning the properties and configuration of the local aquifers, spatial and temporal variations in groundwater levels and groundwater quality data should have been presented in sufficient detail in Chapter 3 to permit a reasonable projection of the effects of the proposed activity on groundwater. Methods (including instrumentation) used to obtain and reduce the data presented should be described. The monitoring program should include those chemical species and characteristics listed in Table 5 that are expected to significantly impair the quality of groundwater.

Models may be used to predict such effects as changes in groundwater levels, dispersion of contaminants, and eventual transport through aquifers to surface water bodies or wells. The models should be described and supporting evidence for their reliability and validity presented.

ATTACHMENT 4

NWC COMMENTS ON COSO MONITORING

Note: Comments are limited to Sec. 3.1

The major differences in the Harding-Lawson Coso Hot Springs Monitoring Plan and the NWC Monitoring program stem from the fact that the two have slightly different objectives. The NWC program is designed to document natural variance of the springs/mud pots and fumaroles, while the Harding-Lawson plan is designed to document this variance plus investigate the hot springs mechanism and to establish, if possible, the connection of the springs to the geothermal reservoir, a somewhat larger task.

Differences in the various studies of the two plans are:

1. Water Temperature
   The Harding-Lawson (H-L) plan proposes continuous water temperature recording; NWC has not considered temperature monitoring except quarterly temperature logging of wells.

2. Meteorological Stations
   The H-L plan proposes complete meteorological stations in the vicinity of the Hot Springs, the NWC program will monitor rainfall only.

3. Pan Evaporation Measurements
   The H-L plan considers evaporation studies, the NWC program does not.

4. Photographic Study of the Mud Pots
   Both the H-L plan and the NWC program require this study.

5. Water Level Recording
   Both the H-L and NWC programs require this study.

6. Water Sampling and Chemical Analysis
   Both programs require this study.

7. Run Off Determinations
   Only the H-L plan considers stream run off.

8. New Wells
   Both the H-L plan and the NWC program propose new wells, however the H-L plan proposes one new well in the alluvium to the west of the surface manifestations while NWC proposes a new well at the Wheeler Prospect, 3 miles south of the Resort. Both plans propose a new well in the alluvium to the east of the Hot Springs Fault. Any new drilling within the Historical Site may have difficulties.

The H-L plan is definitely a more complete monitoring plan, however the NWC program will accomplish the Navy's objective at considerably less cost.

ATTACHMENT 4

[illegible] COMPARISON OF [illegible] MONITORING

Note: Comments are limited to Sec. 5.2

The major differences in the Hartley-Lawson (H-L) and Sykes Monitoring plan and the NRC monitoring program stem from the fact that the two have slightly different objectives. The NRC program is designed to document natural variations of the springs and the Geysers, while the Hartley-Lawson plan is designed to document this variance plus investigate the hot springs as a [illegible]. If possible, any connection of the springs to the geothermal reservoir, a subset of a larger task.

Differences in the specific studies of the two plans are:

1. Water Temperature
   The Hartley-Lawson (H-L) plan proposes continuous water temperature monitoring, NRC proposes periodic temperature monitoring except quarterly [illegible] sampling of wells.

2. Meteorological Stations
   The H-L plan proposes complete meteorological stations in the vicinity of the hot springs, the NRC program will measure rainfall only.

3. Gas [illegible] Measurements
   The H-L plan considers [illegible] studies, the NRC program does not.

4. Photographic Study of the Hot Pots
   Both the H-L plan and the NRC program require this study.

5. Water Level Recording
   Both the H-L and NRC programs require this study.

6. Water Sampling and Chemical Analyses
   Both programs require this study.

7. Hot Pot [illegible]
   Only the H-L plan considers [illegible] the [illegible].

8. New Wells
   Both the H-L plan and the NRC program propose new wells. However the H-L plan proposes one new well in the [illegible] to the east of the surface manifestations while NRC proposes a new well in the [illegible], 3 miles south of the Geysers. Both plans propose a new well at the [illegible] of the [illegible] Ranch. Any new wells within the [illegible] area may have difficulties.

The H-L plan is definitely a more complete monitoring plan. However the NRC program will accomplish the basic objective at considerably less cost.

APPENDIX E

VISUAL RESOURCES

E.1 PRESENT VISUAL SETTING

E.1.1 Landscape Character

All landscapes have a readily identifiable character, regardless of size, location, or land use. Those landscapes that possess or have potential for a greater degree of visual variety are more desirable than those that tend to be monotonous. Each characteristic landscape is determined by the features that are seen and their arrangement in the landscape composition. These landscape features are the landform, vegetation and structures. Each particular feature is defined by the four basic elements of form, line, color and texture. All of the basic elements are present in every landscape, but exert various degrees of visual influence. The more elements that exert a strong visual influence or contrast in the landscape, the stronger or more interesting the landscape character. The degree of variety and harmony among the basic elements determines whether or not a given landscape is pleasant to view.

The Four Basic Elements are described as follows:

Form. Form is generally considered as the mass of an object. It is most strongly expressed in the land surface, usually the result of some type of erosion, but also may be reflected in the openings or changes in vegetation, or in the structures placed on the landscape.

Line. Lines found in the natural landscape are usually the result of an abrupt contrast in form, texture, or color. Lines may be found as ridges, skylines, structures, changes in vegetative types, or individual trees and branches.

Color. Color is a phenomenon or light of visual perception that enables one to distinguish between otherwise identical objects; a hue as contrasted to black, white, or gray. Color as perceived in the landscape is usually most prominent in the vegetation, but may be in the soil, rocks, water, etc., and may vary with the time of day, time of year, and the weather.

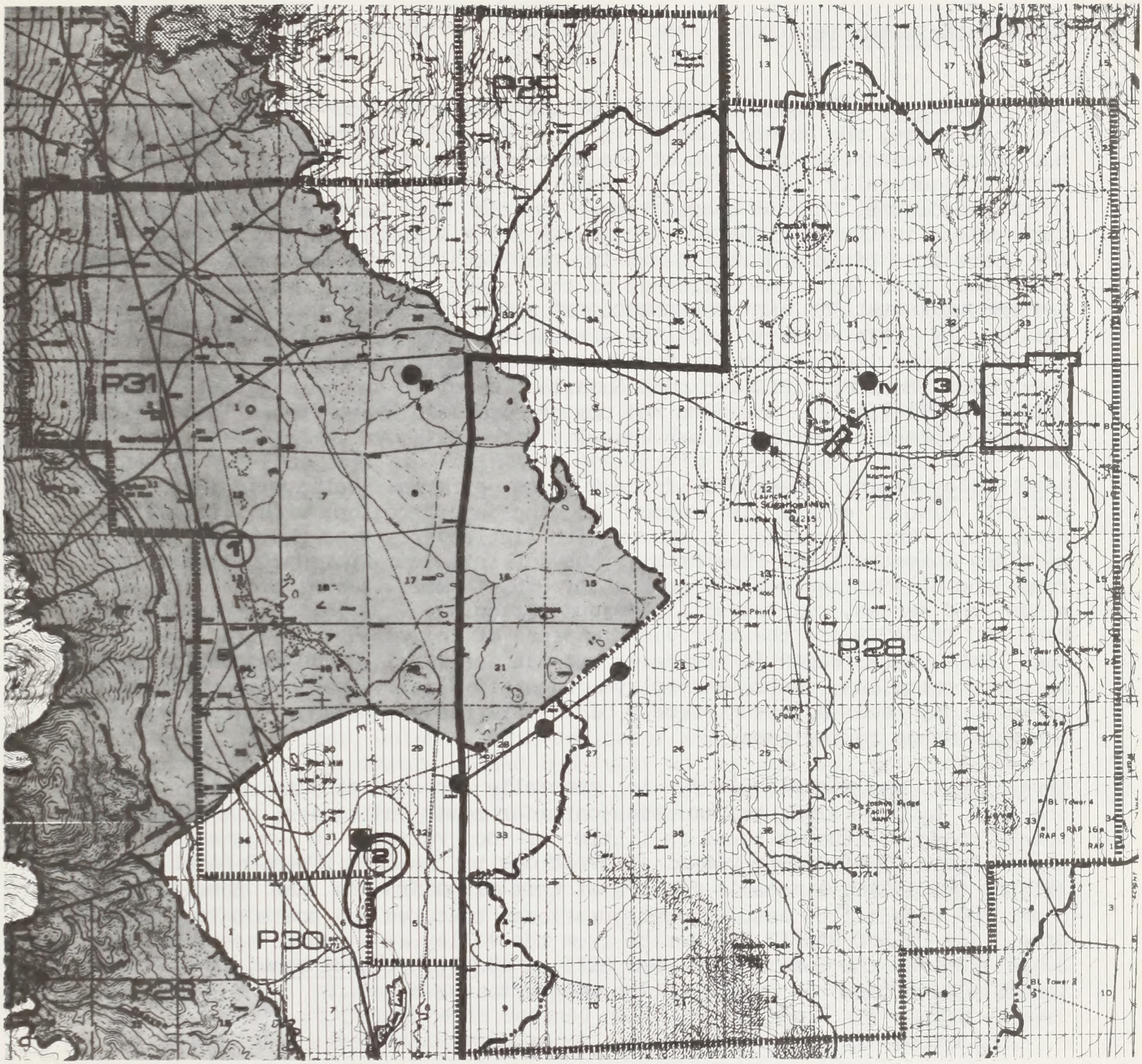
Texture. Texture is the result of size, shape, and placement of parts, their uniformity, and the distance from which they are being observed. Texture, as it is perceived in the landscape, is usually the result of the vegetation patterns on the landscape. Texture also may be the result of erosion patterns in rocks or soil.

E.1.2 Observer Position

Landscape character is determined by viewing portions of the landscape. The placement and relationship of the viewer to the landscape is the "observer position". From this position the extent or area that can be viewed is normally limited by landform, vegetation, or distance. This is the seen area. Those portions of the landscape which are generally not visible from observer positions, and which are beyond approximately 15 miles are the seldom seen areas. In addition, several variables influence visual perception from these observer positions and determine how well contrasts are seen. These variables are: distance, angle of observation, time, size or scale, season of the year, light, and atmospheric conditions.

As observer positions heavily influence the determination of seen or seldom seen areas these positions are carefully selected to fairly represent the viewed portions of the landscape. One or a series of observer positions on a travel route, such as U.S. 395, or at the use area, such as the National Register Site, become "key observation points," (KOP). Rose Valley has been designated as a scenic corridor by the State of California. In seldom seen areas, the observer positions are those which appear to be "likely observation points."

The basic elements of form, line, color and texture are used to describe the landscape features of the CGSA from five "key or likely" observation points (Figure E-1).



KEY OBSERVATION POINTS

1. US 395
2. FOSSIL FALLS
3. COSO HOT SPRINGS

NATIONAL REGISTER SITES

SCENIC QUALITY RATINGS

= A

= B

= C

Fig. E.1

E.1.3 Scenic Quality

The Coso Range. Although two-thirds of the CGSA is of the strong relief of the Coso Range, the scenic quality is of a generally low quality. The complex but sparse vegetation patterns of creosote bush, Joshua Tree and mixed desert scrub are generally insignificant. Numerous intrusions are in evidence on all of the landforms. Graded roads, range targets and testing facilities are instrusions in the HIGH GRANTIC RIDGES AND SLIDE SLOPES. Mining activity with the associated pipes and structures in the Devil's Kitchen area, and the weathered wood and stone buildings of the resort area are intrusions upon the INTERMOUNTAIN VALLEYS AND UPLAND ENCLOSED BASINS (Figure 2.9.1-5). The hot springs of this desert area is a relative water feature. Another notable feature is the localized color found in the soils of the Devil's Kitchen area. The RHYOLITE DOME FIELD includes Sugarloaf Mountain and is a notable feature (Figure 2.9.1-1). The obsidian and pumice deposits in the rubble land flanks of these upland cinder cones are visually interesting.

Rose Valley Plain. One-third of the CGSA is a broad valley in which the overall visual effect is common to the desert region, with little visual diversity. The vegetation is sparse with little variety to the broad expanse of mixed desert shrubs. The area is heavily intruded with numerous unimproved road, the Gil Station highway rest stop, U.S. 395, transmission corridors, mines and fences, cultivated fields and agricultural buildings. The ALLUVIAL FANS AND TERRACES are the most visible areas of the valley (Figure 2.9.1-2). The LOWER VALLEY FLOOR is expansive but not easily viewed in its entirety due to the depressions, sinks, interplaya dunes and flats. The scenic quality is enhanced by the adjacent scenery of the Sierra Nevada Range to the west and the Coso Range to the east.

Lava Flows. The visual quality is generally strong despite being hevily intruded by U.S. 395, transmission corridor roads and towers, pit mining and access roads. Although there is little or no variety in vegetation, the ground plane is of strong visual interest due to the dark LOWLAND BASALT FLOWS (Figure 2.9.1-3). A notable feature of this landform is the Fossil Falls where the basalt flow assumes configurations, textures and scale unique to the area. The UPLAND BASALT FLOWS rise from the valley as a mantle cresting over a portion of the Coso Range. Red Hill, a basaltic cinder cone, is a notable landform with mass and configuration unique to the area.

E.1.4 Visual Resources Inventory

The visual resources of the CGSA were inventoried and evaluated by a system which identifies scenic quality and sets minimum quality standards for management of these resources. This system depends upon three factors:

1. The inherent quality of the scenery being viewed.

2. The visual sensitivity, expressing viewer attitudes toward change and volume of use, of the scenery being viewed.

3. The distance zones representing perception levels by which the scenery is being used.

These factors are used to classify all lands into one of five Visual Resource Management (VRM) classes. Each of these classes contains a specific management objective for maintaining or enhancing visual resource values.

Scenic Quality. Landforms are the key indicators in delineating scenic quality boundaries. All of the scenery within each boundary is all of the same nature. This overall landscape composition is described by the landscape features and their elements of form, line, color, texture. Cultural modifications are also described as visual intrusions or visual improvements and are evaluated and rated as having low, medium, or high visual significance. Each area of distinctive scenery is evaluated, tabulated and rated. The range of scores are grouped into three classes of scenic quality: A, B, and C.

Scenic quality inventories indentified four characteristic landscapes within the CGSA. These four characteric landscapes are delineated on the scenic quality map in Figure E-1 (P28, P29, P30, P31).

Visual Sensitivity/Visual Zones. Visual sensitivity levels indicate the relative degree of user interest in visual resources and concern for changes in the existing landscape character. The criteria for determining visual sensitivity are user volume (both vehicular and pedestrian), and expressed user attitudes toward change. Based upon user volume and user attitude toward change the areas within view of US 395 and the two National Register sites were determined to be highly sensitive to modification (Figure E-2).

Distance zones are determined in the field by actually traveling each route and observing the area that can be viewed. The zones are delineated by the following criteria.

Foreground-Middleground Zone. The area seen from a distance of three to five miles where activities may be viewed in detail. The outer boundary of this zone is defined as the point where the texture and form of individual plants is not longer apparent in the landscape.

Background Zone. This is the remaining area which can be seen from each travel route to approximately 15 miles. Vegetation should be visible at least as patterns of light and dark.

Seldom Seen Zone. These lands are identified as unseen or beyond the approximate 15-mile limit from key observation points.

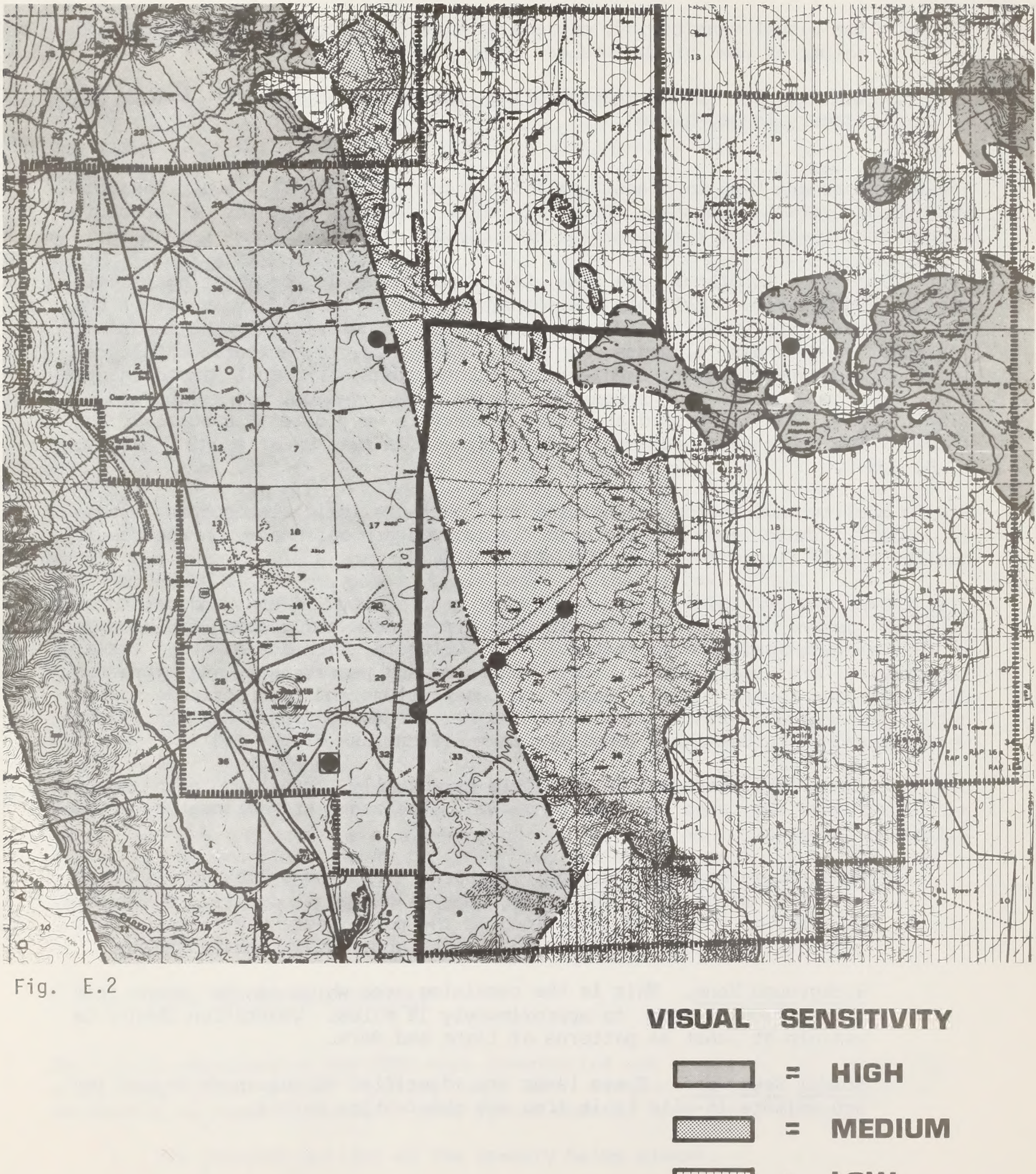


Fig. E.2

VISUAL SENSITIVITY

= HIGH

= MEDIUM

: LOW

Visual Resources Management Classes. Visual resources management classes are management objectives which describe the degree of modification allowed in the basic elements of the landscape. The primary character of the landscape should be retained regardless of the degree of modification. See Figure E-3.

The following is a description of the five VRM class objectives::

Class I. This class provides primarily for natural ecological changes only. It is applied to designated primitive areas, some natural areas, and other similar situations where management activities are to be restricted.

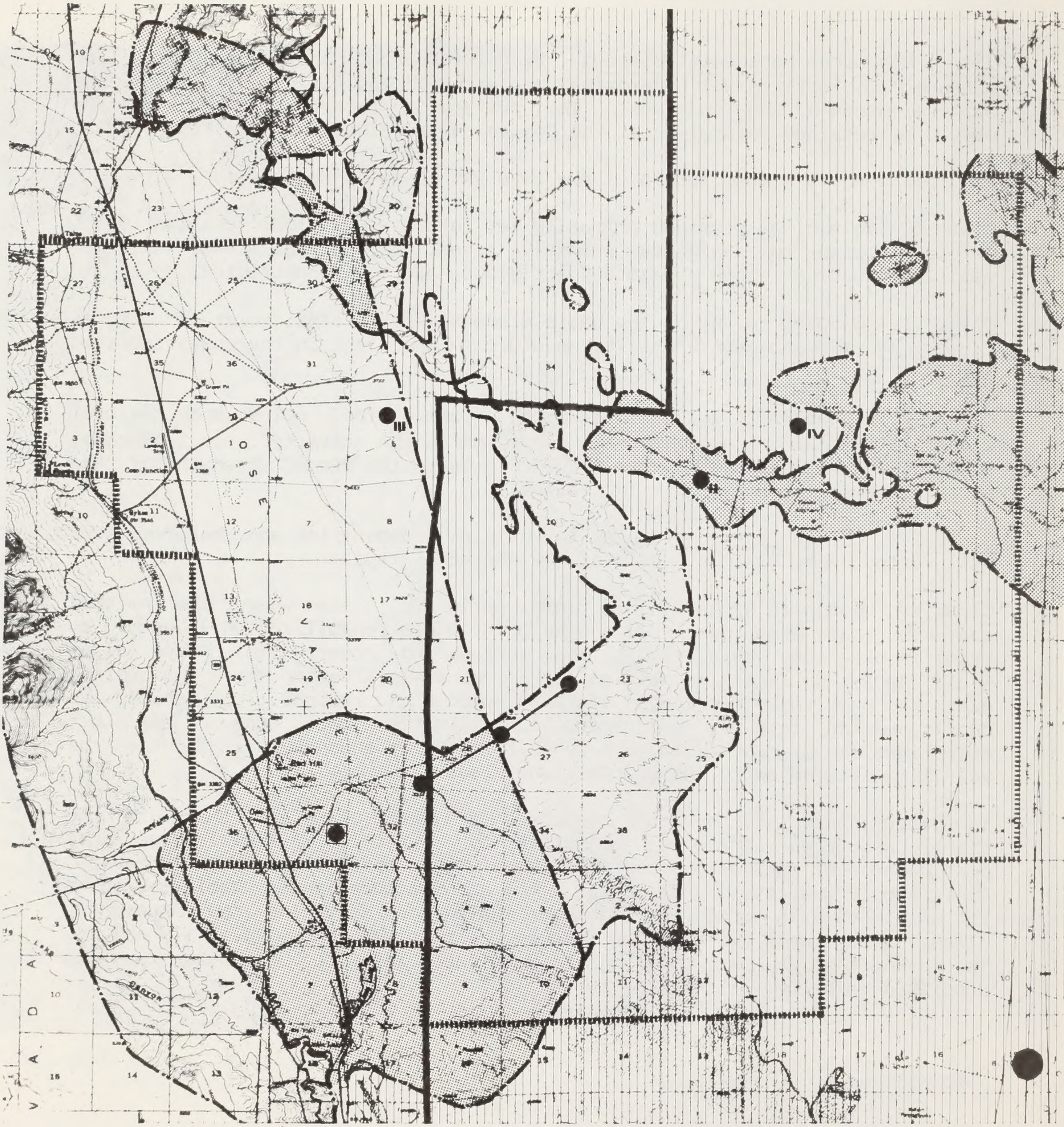
Class II. Changes in any of the basic elements (form, line, color or texture) caused by a management activity should not be evident in the characteristic landscape.

Class III. Changes in the basic elements (form, line, color and texture) caused by a managment activity may be evident in the characteristic landscape. However, the changes should remain subordinate to the visual strength of the existing character.

Class IV. Changes may subordinate the original composition and character but will reflect some basic elements of the character type.

Class V. Change is needed. This class applies to areas where the natural character has been disturbed to the point where rehabilitation is needed to bring it back into character with the surrounding countryside. This class would apply to areas identified in the scenery evaluation where the quality class has been reduced because of unacceptable intrusions. It should be considered an interim, short-term classification until one of the other objectives can be reached through rehabilitation or enhancement. The desired visual quality objective should be identified.

The determination of the visual resources management class and therefore the visual sesources management objective for a particular area is based upon consideraton of the various combinations of the three inventory variables, i.e. scenic quality, visual sensitivity, and distance zones. Table E-1 shows the matrix used in considering these variables to determine the management class. The lands within the CGSA fall within VRM classes II, III, and IV. The methodology use for compiling the data base into the composite map is described in below.



●II VRM CLASS II POWER GENERATING SITE
●III VRM CLASS III POWER GENERATING SITE
●IV VRM CLASS IV POWER GENERATING SITE

VRM CLASS II SWITCHING YARD

●—● VRM CLASS II & III TRANSMISSION CORRIDOR

VISUAL RESOURCE MANAGEMENT CLASSES

= CLASS II

= CLASS III

= CLASS IV

Fig. E.3

Table E-1

Summary of Existing Environment

VRM Class	Land Form	Area (mi2)	Proportion
II	ENCLOSED BASIN of the Coso Range		
	LAVA FLOW of Rose Valley		
	II-B-High-foreground	20	18%
III	BROAD VALLEY PLAIN of Rose Valley		
	III-C-High-Foreground	25	22%
III	SKYLINE SILHOUETTE Of the Coso Range		
	III-B-Medium Background	13.5	11%
IV	ALLUVIAL FAN of Rose Valley		
	IV-C-Medium Background	5	4%
IV	RHYOLITE DOME FIELD HIGH GRANITIC RIDGES of the Coso Range		
	IV-B-Low-Seldom Seen	50	45%
		113.5	100%

E.1.5 Impacts of the Proposed Action on the Visual Setting

Geothermal development could modify the landscape character of the CGSA if striking contrasts occur in the form, line, color or texture of landscape features within areas being viewed. The amount of constrast between a proposed activity and the existing landscape character can be measured by separating the landscape into its major features (land and water surface, vegetation and structures), and then predicting the magnitude of change in constrast of each of the basic elements (form, line, color, and texture) to each of the features.

E.1.6 Visual Contrast Rating

The CGSA is predominantly in natural or near natural condition. The most notable existing cultural modifications extend over a wide area as a network of roadways, transmission corridors, pipelines and fencing. These lengthy intrusions are lineally dispersed and are rated to be realtively insignficant contrasts to form, line, color or texture. Some of the viewed features of the proposed action will be similarly dispersed and will expand this network. Other features of the proposed acton will be visually concentrated at specific sites. These clusters of development culd engender significant constrasts to landscape character. Nor rate for constrast significance are the ephemeral and atmospheric visual features which are attendant to field development. A list of these dispersed, clutered and ephemeral features is provided in Table E-2. Figure E-4 shows the critical viewpoints and visual contrast rating.

TABLE E-2
Dispersed Features of Development

1. Temporary roads
2. Access and maintenance roads
3. Improved roads
4. Water pipelines
5. Insulated steam lines with expansion loops
6. Transmission towers and lines

Clustered Features of Development

1. Graded pads
2. Sumps and pits
3. Drilling rigs
4. Well heads
5. Cooling towers
6. Turbine generation plant
7. Substation
8. Peripheral scarification
9. Parking and martialing areas

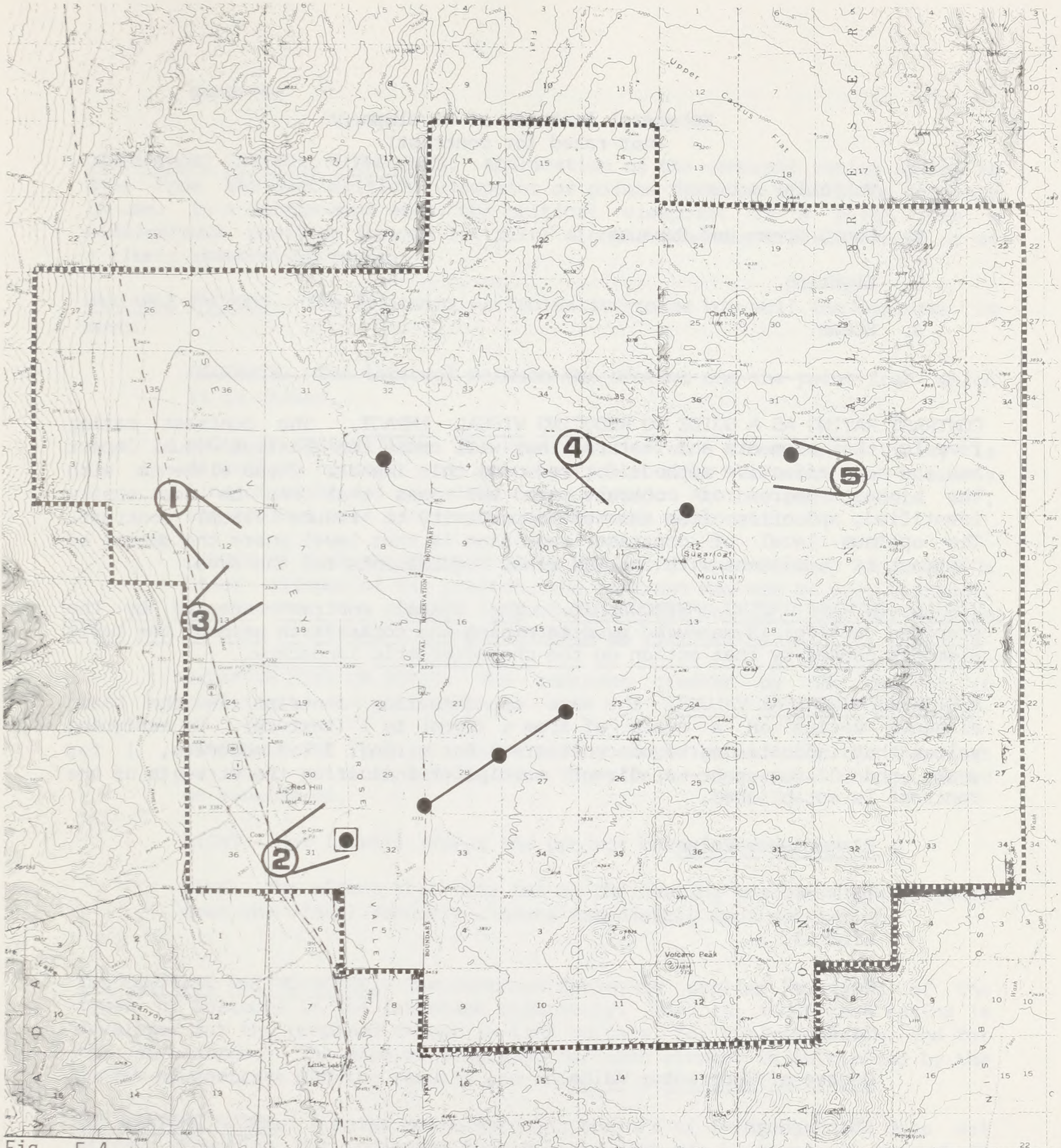


Fig. E.4

CRITICAL VIEWPOINTS

1 U.S. 395
2 U.S. 395
3 U.S. 395
4 COMMONLY TRAVELED ROUTE
5 LIKELY OBSERVATION POINT

VISUAL CONTRAST RATING

- VRM CLASS II POWER GENERATING SITE
- VRM CLASS III POWER GENERATING SITE
- VRM CLASS IV POWER GENERATING SITE
- VRM CLASS II SWITCHING YARD
- VRM CLASS II & III TRANSMISSION CORRIDOR

Ephemeral Features of Development
(not rated for contrast)

1. Vehicular movement

2. Dust, Steam and Exhaust

3. Lighting

4. Steam

CONTRAST RATING AS A GUIDE TO REDUCING VISUAL IMPACT. The contrast rating reveals the elements and features that will cause the greatest visual impact and the most effective methods for reducing this impact. Those elements with the highest degree of contrast are the ones that can be most easily identified, and often offer the most opportunity to reduce visual contrast. The optimum level of contrast reduction is that level where the amount of contrast is consistent with the VRM class requirements for the area.

VISUAL CONTRAST RATING METHODOLOGY. The visual contrast created by the proposed action is measured by determining the contrast in each of the basic elements caused by that action on the characteristic landscape.

ASSIGNING NUMERICAL VALUES. The ease of detecting contrast in the basic elements varies on a scale of from 4 (form) to 1 (texture). By assigning values that indicate degree of contrast--3 for strong, 2 for moderate, 1 for weak, and 0 for none--a direct multiplier indicating the strength of the contrast is established.

Elements- - Value

Form -4

Line -3

Color -2

Texture -1

Degree of Contrast - Value

Strong/High -3

Moderate/Medium -2

Weak/Low -1

None -0

DETERMIMING CRITICAL VIEWPOINTS. Application of the contrast rating system is done from the most critical viewpoint or points that are or will be commonly in use. In a seldon-seen area, the critical viewpoint is a point from a middleground position (beyond 1/4 mile) along a commonly traveled route or at a likely observation point.

VARIABLE FACTORS. The following variables determine how well the contrast is seen:

DISTANCE: The interval between the project and the point from which it is viewed.

ANGLE OF OBSERVATION: The apparent size of a management activity is directly related to the vertical angle between the viewer's line-of-sight and the slope being viewed. At this angle nears 90°, the maximum area is viewable and becomes most critical.

LENGTH OF TIME THE PROJECT IS IN VIEW: If the viewer has only a brief glimpse of the project, the contrast may not be very critical. If, however, the project is subject to view for a long period, as from an overlook, the contrast becomes very critical.

RELATIVE SIZE OR SCALE: The contrast created by the project in relation to its surroundings.

SEASON OF THE YEAR: Contrast rating should be made for the heaviest or most critical use season. The effects of seasonal change should be considered.

LIGHT: How it will affect the project being viewed.

TIME: The effect that time has on the healing process. Few projects meet the visual resource classes immediately upon completion.

THE CONTRAST RATING SCORE. The contrast rating is applied to each of the types of features in the landscape separately. That is, a contrast rating is developed for the proposed change in land surface, for the vegetation, and for the structures. The ease of detection for each element is multiplied by the degree of contrast and the results are added to get a total score.

THE FEATURE SCORE. A total score for each feature of 1 through 10 does not attract attention, but indicates that the contrast can be seen; 11 through 20 attracts attention, and the contrast begins to dominate the characteristic landscape; 21 through 30 demands attention, and will not be overlooked. The acceptable range of scores for each feature varies according to the requirements of each VRM class in which the proposed action is to occur.

CLASS I - not to exceed 10

CLASS II - not to exceed 12

CLASS III - not to exceed 16

CLASS IV - not to exceed 20

CLASS V - (an interim class is not scored).

E.1.7 Insignificant Impacts

The contrast rating reveals that geothermal development would not significantly affect all three landscape features to the same degree. Due to the variable factors of distance and relative scale, the impact upon the form, line, color or texture of LANDFORM would be insignificant. The extent of change to the existing landforms caused by all grading activity would not significantly affect the major elements of form and line; however, minor affects would be visible in changes in color and texture.

More significant would be the impacts of scarification of VEGETATION which would notably interrupt line, color and texture, while form would remain nearly unchanged. Significant contrasts would be found in the basic elements of STRUCTURES.

E.1.8 Significant Impacts

Striking differences in form and line would occur with the introduction of geothermal development STRUCTURES. To a slightly lesser degree, color and texture would also be effected. The contrast in all the basic elements would most notably occur as follows:

FORM - Mass and angular shadows would appear on the floor of basins and valleys where they had not previously occurred. The variable factors of distance, relative scale, period of observation, and light would all diffuse or accent this contrast throughout the daylight cycle.

LINE - Horizontal lines typical of basins and valley floors would be interrupted or made discontinuous altogether. Conversely, much of the intermittent line quality would be overlaid with long, unrelieved linear networks and corridors extending entirely across the area being viewed.

COLOR - Contrasts in color would occur as flecks of contrast interrupting the existing mosaic. In some cases, brightly hued colors would be quite assertive.

TEXTURE - Contrasts in texture would be the least noticeable of the elements, as relative scale prevents surface texture of structure from becoming visually significant. Interruptions in existing patterns and mosaics would be of significance.

E.1.9 Simulation of Impacts

Since the location and description of this project is not well defined five situations which were considered to be "typical" for each of the landscape character types were chosen for purpose of impact analysis and evaluated from the most critical location under the most critical viewing conditions. Figures 2.9.2-1 through 2.9.2-5 (see Chapter 2) are visual simulations of these five situations. These evaluations assume full development which would be the worst case and most long term situation. The geothermal development features which are illustrated are a power generating, site a transmission corridor and an electrical substation.

E.1.10 Worksheets

The Visual Contrast Rating Worksheets for the power generating sites, transmission corridor, and switching yard/substation follow.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

VISUAL CONTRAST RATING WORKSHEET

Date	7/31/79
District	Bakersfield
Planning unit	Desert
Activity	Geothermal Leasing

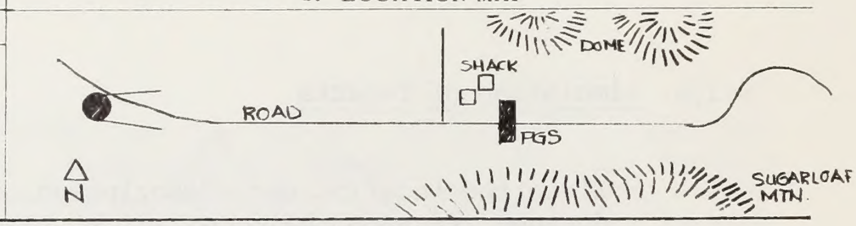
SECTION A. PROJECT INFORMATION

1. Project name	2. Critical viewpoint number	3. MFP Step III VRM class
POWER GENERATING SITE II	4	II

4a. LOCATION

TOWNSHIP	RANGE	SECTION
22S	38E	1

b. LOCATION MAP



SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

1. LAND/WATER	FORM	Broad, flat, open basin floor with notable absence of form. Massive rounded domes border and enclose open basin floor.
	LINE	Undulating, steepsided domes converging on horizontal, flattened basin floor.
	COLOR	Predominantly dull beige, buff and tan accented with mottled reddish browns, sepia and grey-white.
	TEXTURE	Stone & boulder rubble land on toe slopes and side slops are uniform, fine textures.
2. VEGETATION	FORM	Low, open and sparse clumping. Minimal form.
	LINE	Horizontal striations changing to complex, random patterns.
	COLOR	Dull grey-green, bronze and ochre mosaic.
	TEXTURE	Fine, stiff varying to tufted and patchy.
3. STRUCTURES	FORM	Low, roofed, blocky.
	LINE	Rectilinear, angular.
	COLOR	Weathered, dark umber wood, galvanized medium grey.
	TEXTURE	Rough.

(Continued on page 2)

Form 8400-4 (September 1978)
U.S. Government Printing Office [illegible]

SECTION C. PROPOSED ACTIVITY DESCRIPTION

(Refer to BLM Manual Section 8131 for proposed descriptions and requirements)

1. LAND/WATER	FORM	Flattened, slightly mounding to lumpy.
	LINE	Irregular, discontinuous,jagged, horizontal.
	COLOR	Grey to white.
	TEX-TURE	Uneven.
2. VEGETATION	FORM	Interrupted bands and patterns.
	LINE	Sharp horizontal line, discontinuous patterns.
	COLOR	Grey to white.
	TEX-TURE	Uneven.
3. STRUCTURES	FORM	Massive, cubical, horizontal with rounded verticals.
	LINE	Parabolic and rectilinear.
	COLOR	Bright, grey to white, sharp shadow contrast.
	TEX-TURE	Smooth to metallic.

SECTION D. CONTRAST RATING [ ] SHORT TERM [X] LONG TERM

DEGREE OF CONTRAST	LAND/WATER BODY (1)				VEGETATION (2)				STRUCTURES (3)			
ELEMENTS	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)
Form (4x)	12	8	**4**	0	12	8	**4**	0	**12**	8	4	0
Line (3x)	9	6	**3**	0	9	6	3	**0**	9	**6**	3	0
Color (2x)	6	4	**2**	0	6	4	**2**	0	6	**4**	2	0
Texture (1x)	3	2	**1**	0	3	2	**1**	0	3	2	**1**	0
TOTALS	10				7				23			

1a. Maximum element contrast

Moderate

b. Maximum feature contrast

12

2. Does project design meet visual resource management requirements? [ ] Yes [X] No

If "no," (or if rating is over maximum allowable) redesign project in section E, concentrating on feature/element of greatest contrast. If contrast is acceptable, this does not prelude additional mitigating measures; propose as stipulations, and list in section E.

Evaluator *(signature)* Greg Arthur

Date 7/31/79

SECTION E. REDESIGN, STIPULATIONS, MITIGATING MEASURES

Landform: Restrict earthwork to linear configurations with no major cuts, fills, or excavations.

Vegetation: Restrict denudation to intermittent, linear configuration.

Structure: Restrict height of above grade structures to one story.
No structure shall break the skyline or be silhouetted on the basin floor where no background support exists.
No angular corners where vertical surfaces connect with horizontal surfaces.
Linear network features to follow existing linear land forms, i.e. edges of basins.
Use sloping walls to reduce the effect of incompatible shadow patterns.Non-reflective earth tone colors.
Arrange structures in compact configurations to avoid unnecessary dispersal.
Dull, non-reflective earth tones.
Locate ancillary structures behind larger structures out of line of sight.

SECTION F. DESCRIPTION OF ACTIVITY *(Redesigned)*

1. LAND/WATER	FORM	Flattened, slightly mounding.
	LINE	Irregular and rounded.
	COLOR	Grey-tans-whites-browns.
	TEXTURE	Even.
2. VEGETATION	FORM	Interrupted pattern.
	LINE	Patchy bands.
	COLOR	Grey greens and tans.
	TEXTURE	Uneven.
3. STRUCTURES	FORM	Domed or sloping-side shell.
	LINE	Mounding.
	COLOR	Green-grey-tan, non-reflective.
	TEXTURE	Fine, even, not metallic.

(Continued on page 4)

SECTION G. CONTRAST RATING *(Redesigned)*

DEGREE OF CONTRAST	FEATURES: LAND/WATER BODY (1)				VEGETATION (2)				STRUCTURES (3)			
ELEMENTS	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)
Form (4x)	12	8	4	0	12	8	4	0	12	8	4	0
Line (3x)	9	6	3	0	9	6	3	0	9	6	3	0
Color (2x)	6	4	2	0	6	4	2	0	6	4	2	0
Texture (1x)	3	2	1	0	3	2	1	0	3	2	1	0
TOTALS	10				7				19			

1a. Maximum element contrast

Moderate

b. Minimum feature contrast

12

2. Does project design meet visual resource management requirements? ☐ Yes ■ No

If "no," request services of district landscape architect, and describe amount of time and when required.

3. Fiscal year

19

4. Which third? *(check one)*

☐ First ☐ Second ☐ Third

5. TIME REQUIRED

DAYS	MAN-MONTHS

SECTION H. RECOMMENDATIONS

1. Recommendation of staff landscape architect if allowable contrast rating cannot be met

Signature | Date

2. Decision and justification of Area or District Manager

Signature | Date

3. Check appropriate box: ☐ Proceed with project/activity as mitigated ☐ Cancel project/activity as proposed

Signature | Date

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

VISUAL CONTRAST RATING WORKSHEET

Date	7/31/79
District	Bakersfield
Planning unit	Desert
Activity	Geothermal Leasing

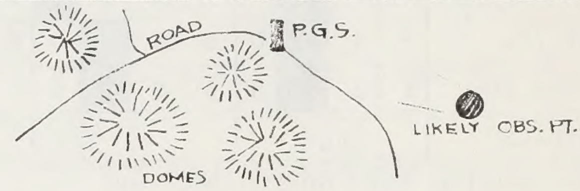
SECTION A. PROJECT INFORMATION

1. Project name	2. Critical viewpoint number	3. MFP Step III VRM class
POWER GENERATING SITE IV	5	IV

4a. LOCATION

TOWNSHIP	RANGE	SECTION
22S	39E	6

b. LOCATION MAP



SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

1. LAND/WATER	FORM	Open basin with depressions and minimal formation; enclosed by massive, steep-sided domes and toe slopes of granitic ridges.
	LINE	Mixture of symmetrical and complex, assymetrical, irregular slopes & skyline. Symmetrical domes and slopes converging on basin floor with zig-zag toe slopes of granitic ridges.
	COLOR	Dull, mottled grey and tan sharply separated from the much darker hued reddish browns of the rhyolite domes.
	TEXTURE	Uniformly even, rubble land stones and boulders at toe of slopes of domes contrast with fine texture of basin and more coarse texture of granitic ridge rubble land.
2. VEGETATION	FORM	Sparse, low, clumping with minimal form.
	LINE	Patchy, irregular, lightly striated, and low vertical accents by Joshua Trees.
	COLOR	Olive and grey green, sharp dark accents by Joshua Trees.
	TEXTURE	Mosaic of fine uniformly even areas and complex coarse, uneven areas.
3. STRUCTURES	FORM	None
	LINE	None
	COLOR	None
	TEXTURE	None

(Continued on page 2)

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SECTION C. PROPOSED ACTIVITY DESCRIPTION

(Refer to BLM Manual Section 8131 for proposed descriptions and requirements)

1. LAND/WATER	FORM	Flattened to mounding.
	LINE	Angular, discontinuous.
	COLOR	Grey to white.
	TEXTURE	Uneven.
2. VEGETATION	FORM	Interrupted pattern.
	LINE	Horizontal line.
	COLOR	Grey to white.
	TEXTURE	Uneven.
3. STRUCTURES	FORM	Long rectilinear shell with protruding towers.
	LINE	Parabolic and rectilinear.
	COLOR	Grey to white.
	TEXTURE	Smooth to metallic.

SECTION D. CONTRAST RATING ☐ SHORT TERM ■ LONG TERM

DEGREE OF CONTRAST	LAND/WATER BODY (1)				VEGETATION (2)				STRUCTURES (3)			
ELEMENTS	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)
Form (4x)	12	**8**	4	0	12	8	**4**	0	**12**	8	4	0
Line (3x)	9	**6**	3	0	9	**6**	3	0	9	**6**	3	0
Color (2x)	6	**4**	2	0	6	**4**	2	0	6	**4**	2	0
Texture (1x)	3	**2**	1	0	3	**2**	1	0	3	**2**	1	0
TOTALS	20				16				24			

1a. Maximum element contrast

Moderate

b. Maximum feature contrast

24

2. Does project design meet visual resource management requirements? ☐ Yes ■ No
If "no," (or if rating is over maximum allowable) redesign project in section E, concentrating on feature/element of greatest contrast. If contrast is acceptable, this does not prelude additional mitigating measures; propose as stipulations, and list in section E.

Evaluator *(signature)* [signature]

Date 7-31-79

SECTION E. REDESIGN, STIPULATIONS, MITIGATING MEASURES

Landform:	Taper or round all slopes and berms. Restore rubble land texture to exposed slopes adjacent to rubble land.
Vegetation:	Restrict denudation to linear confirurations.
Structures:	Dome-like structures with sloping sides. Reduce height of all structures by using berms and subterranean construction. Dull, non-reflective earth tones. Textured wall surfaces.

SECTION F. DESCRIPTION OF ACTIVITY *(Redesigned)*

1. LAND/WATER	FORM	Flattened to mounding.
	LINE	Rounded, soft, horizontal flowing with contours.
	COLOR	Greys, tans, red-browns.
	TEXTURE	Even, uniform.
2. VEGETATION	FORM	Interrupted pattern.
	LINE	Irregular.
	COLOR	Patchy grey-greens and tans.
	TEXTURE	Uneven.
3. STRUCTURES	FORM	Domed or sloping-side shell.
	LINE	Softly rounded.
	COLOR	Greys, tans, red-browns, non-reflective.
	TEXTURE	Even, not-metallic.

(Continued on page 4)

SECTION G. CONTRAST RATING *(Redesigned)*

DEGREE OF CONTRAST		FEATURES											
		LAND/WATER BODY (1)				VEGETATION (2)				STRUCTURES (3)			
		Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)
ELEMENTS	Form (4x)	12	8	4	0	12	8	4	0	12	8	4	0
	Line (3x)	9	6	3	0	9	6	3	0	9	6	3	0
	Color (2x)	6	4	2	0	6	4	2	0	6	4	2	0
	Texture (1x)	3	2	1	0	3	2	1	0	3	2	1	0
TOTALS		17				16				20			

1a. Maximum element contrast

Moderate

b. Minimum feature contrast

20

2. Does project design meet visual resource management requirements? ☒ Yes ☐ No

If "no," request services of district landscape architect, and describe amount of time and when required.

3. Fiscal year

19

4. Which third? *(check one)*

☐ First ☐ Second ☐ Third

5. TIME REQUIRED	
DAYS	MAN-MONTHS

SECTION H. RECOMMENDATIONS

1. Recommendation of staff landscape architect if allowable contrast rating cannot be met

Signature	Date

2. Decision and justification of Area or District Manager

Signature	Date

3. Check appropriate box: ☐ Proceed with project/activity as mitigated ☐ Cancel project/activity as proposed

Signature	Date

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

VISUAL CONTRAST RATING WORKSHEET

Date	7/31/79
District	Bakersfield
Planning unit	Desert
Activity	Geothermal Leasing

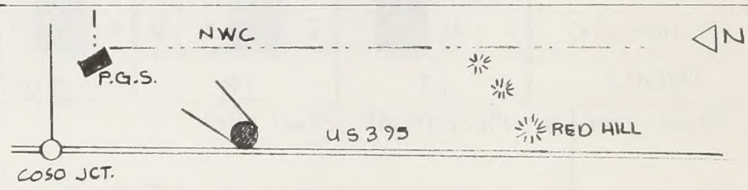
SECTION A. PROJECT INFORMATION

1. Project name	2. Critical viewpoint number	3. MFP Step III VRM class
Power Generating Site III	3	III

4a. LOCATION

TOWNSHIP	RANGE	SECTION
22S	38E	5

b. LOCATION MAP



SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

1. LAND/WATER	FORM	Notable absence of form on broad, open valley floor with some depressions. Broadly spreading alluvial fan. Complex 1.
	LINE	Nearly level valley floor changing to gently mounding alluvial fan. Complex furrowing with strong V-shapes and irregular undulating skyline.
	COLOR	Mottled tans and grey-white with little variety.
	TEXTURE	Uniformly fine in level areas changing to soft, rounded complex furrowing with medium texture.
2. VEGETATION	FORM	Low,open, clumping with minimal form. A thin veneer on the valley floor.
	LINE	Horizontal striations lightly traced over broad band.
	COLOR	Dull grey-green, ochre with little variety.
	TEXTURE	Uniformly fine and even.
3. STRUCTURES	FORM	Angular, open-fabrication, steel towers at regular intervals.
	LINE	Tall. vertical tracery with faint, swayback connecting wires.
	COLOR	Grey.
	TEXTURE	Smooth metallic.

(Continued on page 2)

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SECTION C. PROPOSED ACTIVITY DESCRIPTION

(Refer to BLM Manual Section 8131 for proposed descriptions and requirements)

1. LAND/WATER	FORM	Flattened, slightly mounding to lumpy.
	LINE	Irregular and angular.
	COLOR	Grey to white.
	TEX-TURE	Uneven.
2. VEGETATION	FORM	Patterns interrupted and lost.
	LINE	Horizontal line aspect.
	COLOR	Grey to white.
	TEX-TURE	Fine textured mosaic interrupted by irregular flecks.
3. STRUCTURES	FORM	Long rectilinear shell with towers.
	LINE	Parabolic and rectilinear.
	COLOR	Grey to white, some reflective.
	TEX-TURE	Smooth to metallic.

SECTION D. CONTRAST RATING ☐ SHORT TERM ■ LONG TERM

DEGREE OF CONTRAST		LAND/WATER BODY (1) Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	VEGETATION (2) Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	STRUCTURES (3) Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)
ELEMENTS	Form (4x)	12	8	4	0	12	8	4	0	12	8	4	0
	Line (3x)	9	6	3	0	9	6	3	0	9	6	3	0
	Color (2x)	6	4	2	0	6	4	2	0	6	4	2	0
	Texture (1x)	3	2	1	0	3	2	1	0	3	2	1	0
TOTALS		10				3				19			

1a. Maximum element contrast

Moderate

b. Maximum feature contrast

16

2. Does project design meet visual resource management requirements? ☐ Yes ■ No

If "no," (or if rating is over maximum allowable) redesign project in section E, concentrating on feature/element of greatest contrast. If contrast is acceptable, this does not prelude additional mitigating measures; propose as stipulations, and list in section E.

Evaluator *(signature)* Greg Arthur

Date 7/31/79

SECTION E. REDESIGN, STIPULATIONS, MITIGATING MEASURES	
Landform:	Earthwork restricted to excavation of sumps, reserve and disposal pits. Cut & fill activities limited to road alignments.
Vegetation:	Not significant.
Structures:	Structures arranged in compact configurations to avoid unnecessary dispersal. Above grade height reduced by a combination of berms and subterranean construction. No structures protrude above skyline. Dull, non-reflective earth tone colors. Locate ancillary structures behind larger structures out of line of sight from critical viewpoints. Use sloping walls to reduce the effect of incompatible shadow patterns. All visible wall surfaces to be rough textured.

SECTION F. DESCRIPTION OF ACTIVITY *(Redesigned)*		
1. LAND/WATER	FORM	Flattened, slightly mounding.
	LINE	Irregular and rounded.
	COLOR	Greys-tans-whites.
	TEXTURE	Even.
2. VEGETATION	FORM	Interrupted pattern and lost.
	LINE	Intermittent bands.
	COLOR	Grey-greens and tans.
	TEXTURE	Fine textured mosaic interrupted by irregular flecks.
3. STRUCTURES	FORM	Series of low, rounded horizontal forms.
	LINE	Mounding, undulating.
	COLOR	Grey-greens and tans, non-reflective.
	TEXTURE	Fine, even - not metallic.

(Continued on page 4)

SECTION G. CONTRAST RATING *(Redesigned)*

DEGREE OF CONTRAST		LAND/WATER BODY (1) Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	VEGETATION (2) Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	STRUCTURES (3) Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)
ELEMENTS	Form (4x)	12	8	4	0	12	8	4	0	12	8	4	0
	Line (3x)	9	6	3	0	9	6	3	0	9	6	3	0
	Color (2x)	6	4	2	0	6	4	2	0	6	4	2	0
	Texture (1x)	3	2	1	0	3	2	1	0	3	2	1	0
TOTALS		10				3				16			

1a. Maximum element contrast

Moderate

b. Minimum feature contrast

16

2. Does project design meet visual resource management requirements? ☒ Yes ☐ No

If "no," request services of district landscape architect, and describe amount of time and when required.

3. Fiscal year 19

4. Which third? *(check one)* ☐ First ☐ Second ☐ Third

5. TIME REQUIRED

DAYS	MAN-MONTHS

SECTION H. RECOMMENDATIONS

1. Recommendation of staff landscape architect if allowable contrast rating cannot be met

Signature | Date

2. Decision and justification of Area or District Manager

Signature | Date

3. Check appropriate box: ☐ Proceed with project/activity as mitigated ☐ Cancel project/activity as proposed

Signature | Date

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

VISUAL CONTRAST RATING WORKSHEET

Date	7/31/79
District	Bakersfield
Planning unit	Desert
Activity	Geothermal Leasing

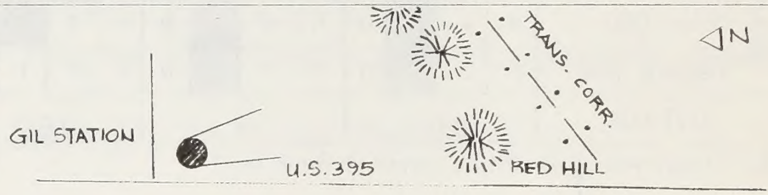
SECTION A. PROJECT INFORMATION

1. Project name	2. Critical viewpoint number	3. MFP Step III VRM class
TRANSMISSION CORRIDOR	I	IV

4a. LOCATION

TOWNSHIP	RANGE	SECTION
22S	38E	13,14,22, 23,27,28, 29,31,32

b. LOCATION MAP



SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

1. LAND/WATER	FORM	Broad, open valley floor with slight depressions and notable absence of form. Distant massive domes and cinder cones.
	LINE	Broad flat banded with no line quality. Distant undulating and complexly furrowed skyline. Intermittent striations of disturbed surface below existing transmission corridor.
	COLOR	Undistinctive tans and greys sharply contrasting with red browns of cinder cones and brown, blacks of lava flows. White striations of disturbed surface.
	TEXTURE	Very fine, even, and uniform contrasted with distant medium texture of furrowed and shadowed Coso Mountains.
2. VEGETATION	FORM	Low, open clumps and tufts with minimal form. A thin veneer covering the valley floor.
	LINE	Broad bands subtly striated with some patchiness.
	COLOR	Ochre and grey-green with distant patches of olice. Little variation.
	TEXTURE	Uniform, even and fine.
3. STRUCTURES	FORM	Angular, open-fabrication, steel towers at regular intervals.
	LINE	Tall, vertical tracery with faint, sagging wire linkage.
	COLOR	Grey.
	TEXTURE	Smooth metallic.

(Continued on page 2)

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SECTION C. PROPOSED ACTIVITY DESCRIPTION

(Refer to BLM Manual Section 8131 for proposed descriptions and requirements)

1. LAND/WATER	FORM	Slight linear depression.
	LINE	Slight interrupted striation.
	COLOR	Grey-white striation and flecks of lighter color.
	TEXTURE	Slight interruption.
2. VEGETATION	FORM	Flecks of "valley floor veneer" lost.
	LINE	Slight striation indicating denudation.
	COLOR	Flecks of white-grey indicating denudation.
	TEXTURE	Irregular flecks.
3. STRUCTURES	FORM	Angular, open fabrication, steel towers at regular intervals.
	LINE	Vertical tracery with faint, sagging connecting lines.
	COLOR	Grey.
	TEXTURE	Smooth, metallic.

SECTION D. CONTRAST RATING ☐ SHORT TERM ■ LONG TERM

DEGREE OF CONTRAST		FEATURES											
		LAND/WATER BODY (1)				VEGETATION (2)				STRUCTURES (3)			
		Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)
ELEMENTS	Form (4x)	12	8	4	**0**	12	8	4	**0**	12	8	4	**0**
	Line (3x)	9	6	3	**0**	9	6	**3**	0	9	6	3	**0**
	Color (2x)	6	4	**2**	0	6	4	**2**	0	6	4	2	**0**
	Texture (1x)	3	2	1	**0**	3	2	1	**0**	3	2	1	**0**
TOTALS		2				5				0			

1a. Maximum element contrast

Moderate

b. Maximum feature contrast

16

2. Does project design meet visual resource management requirements? ■ Yes ☐ No

If "no," (or if rating is over maximum allowable) redesign project in section E, concentrating on feature/element of greatest contrast. If contrast is acceptable, this does not prelude additional mitigating measures; propose as stipulations, and list in section E.

Evaluator *(signature)* Greg Arthur

Date 7/31/79

SECTION E. REDESIGN, STIPULATIONS, MITIGATING MEASURES

Landform: Utilize existing road right-of-ways for corridor maintenance roads as much as practical.

Vegetation: Not significant.

Structures: Structures will be located so that they will not protrude above the skyline.

Structures painted with dull, non-reflective, earth tone colors compatible with the grey-green, tans, basalt browns and reds and greys of the area. Mottled coloration would be preferred above uniform coloration.

SECTION F. DESCRIPTION OF ACTIVITY *(Redesigned)*

1. LAND/WATER	FORM	
	LINE	
	COLOR	
	TEX-TURE	
2. VEGETATION	FORM	
	LINE	
	COLOR	
	TEX-TURE	
3. STRUCTURES	FORM	
	LINE	
	COLOR	
	TEX-TURE	

(Continued on page 4)

SECTION G. CONTRAST RATING *(Redesigned)*

DEGREE OF CONTRAST		LAND/WATER BODY (1) Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	VEGETATION (2) Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	STRUCTURES (3) Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)
ELEMENTS	Form (4x)	12	8	4	0	12	8	4	0	12	8	4	0
	Line (3x)	9	6	3	0	9	6	3	0	9	6	3	0
	Color (2x)	6	4	2	0	6	4	2	0	6	4	2	0
	Texture (1x)	3	2	1	0	3	2	1	0	3	2	1	0
TOTALS													

1a. Maximum element contrast

b. Minimum feature contrast

2. Does project design meet visual resource management requirements? ☐ Yes ☐ No

If "no," request services of district landscape architect, and describe amount of time and when required.

3. Fiscal year

19

4. Which third? *(check one)*

☐ First ☐ Second ☐ Third

5. TIME REQUIRED	
DAYS	MAN-MONTHS

SECTION H. RECOMMENDATIONS

1. Recommendation of staff landscape architect if allowable contrast rating cannot be met

Signature	Date

2. Decision and justification of Area or District Manager

Signature	Date

3. Check appropriate box: ☐ Proceed with project/activity as mitigated ☐ Cancel project/activity as proposed

Signature	Date

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

VISUAL CONTRAST RATING WORKSHEET

Date	7/31/79
District	Bakersfield
Planning unit	Desert
Activity	Geothermal Leasing

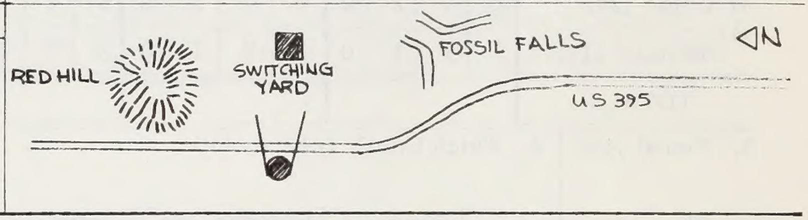
SECTION A. PROJECT INFORMATION

1. Project name	2. Critical viewpoint number	3. MFP Step III VRM class
SWITCHING YARD/SUBSTATION	2	II

4a. LOCATION

TOWNSHIP	RANGE	SECTION
22S	38E	31

b. LOCATION MAP



SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

1. LAND/WATER	FORM	Broad open valley floor with some despressions & general absence of form, excepting the thin linear bands of irregular & rugged lava flow silhouettes. Strongly rounded & furrowed domes in distance.
	LINE	Alluvial fans slope down frm.right to left & lava flows slope down frm. left to right form converging lines.Steeply rounded dome lines w/complex furrows converge on striated valley flr.Undulating skyline.
	COLOR	Mottled,dull tans & greys sharply contrast with with deep black browns of basaltic flows & red browns of cinder cones. Distant dark grey shadings of obsidian outcrops are distinct against tans of domes.
	TEX-TURE	Uneven ruggedness of lava flows are coarse. Valley floor & alluvial fans are even and fine. Complex furrowing on domes are soft, rounded mosaic of fine and medium textures.
2. VEGETATION	FORM	Low, open clumping & tufts with minimal form. A thin veneer on the valley floor.
	LINE	Broad mosaic of irregular bands and distant striations.
	COLOR	Ochre and grey green with relative variety.
	TEX-TURE	Uniformly even and fine.
3. STRUCTURES	FORM	Angular, open-fabrication, steel towers at regular intervals.
	LINE	Tall vertical tracery with faint, sagging connecting wires.
	COLOR	Grey.
	TEX-TURE	Smooth, metallic.

(Continued on page 2)

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SECTION C. PROPOSED ACTIVITY DESCRIPTION

(Refer to BLM Manual Section 8131 for proposed descriptions and requirements)

1. LAND/WATER	FORM	Flat, with angled slopes.
	LINE	Straight, horizontal, angular.
	COLOR	Basalt brown to grey-white.
	TEXTURE	Irregular, medium.
2. VEGETATION	FORM	Valley floor "veneer" interrupted and lost.
	LINE	Striations from denudation.
	COLOR	Grey to white.
	TEXTURE	Medium.
3. STRUCTURES	FORM	Cubicle with some open fabrication.
	LINE	Rigid, irregular, rectilinear contrasted with softly parabolic connector lines.
	COLOR	Light to dark grey, some reflective.
	TEXTURE	Varies from smooth metallic to textured metal mesh.

SECTION D. CONTRAST RATING ☐ SHORT TERM ☒ LONG TERM

DEGREE OF CONTRAST	LAND/WATER BODY (1) Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	VEGETATION (2) Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	STRUCTURES (3) Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)
ELEMENTS: Form (4x)	12	8	**4**	0	12	8	**4**	0	12	**8**	4	0
Line (3x)	9	6	**3**	0	9	6	**3**	0	9	6	**3**	0
Color (2x)	6	**4**	2	0	6	4	**2**	0	6	4	**2**	0
Texture (1x)	3	2	**1**	0	3	2	**1**	0	3	2	**1**	0
TOTALS	12				10				14			

1a. Maximum element contrast

Moderate

b. Maximum feature contrast

12

2. Does project design meet visual resource management requirements? ☐ Yes ☒ No

If "no," (or if rating is over maximum allowable) redesign project in section E, concentrating on feature/element of greatest contrast. If contrast is acceptable, this does not prelude additional mitigating measures; propose as stipulations, and list in section E.

Evaluator *(signature)*

Date

SECTION E. REDESIGN, STIPULATIONS, MITIGATING MEASURES

Landform:	Earthwork restricted to linear configurations which do not require cuts and fills or excavations. Restore desert patina to critical segments of exposed land surfaces with non-toxic stains.
Vegetation:	Restrict denudation to intermittent, linear configuration.
Structures:	Structures with significant form restricted from this area. This includes structures over one story in height and those with long, unrelieved roof lines. Structures located so as to not protrude above the skyline on open basin floors. Locate structures in proximity to other existing forms,if they exist. Structures should not be silhoutted where no background support exists. Coloration should be dull,non-reflective, earth tones compatible with grey-greens, tans, basalt browns and reds and greys of the area.

SECTION F. DESCRIPTION OF ACTIVITY *(Redesigned)*

1. LAND/WATER	FORM	Flat.
	LINE	Intermittent, irregular.
	COLOR	Basalt brown to grey-white.
	TEXTURE	Medium.
2. VEGETATION	FORM	Flat surface veneer interrupted and lost.
	LINE	Striations from denudation.
	COLOR	Grey and tan striations.
	TEXTURE	Medium.
3. STRUCTURES	FORM	Interrupted rectilinear with open fabrication in 2nd story.
	LINE	Irregular and open.
	COLOR	Dark, basalt brown base with grey-green and ochre upper structure, non-reflective.
	TEXTURE	Textured metal mesh.

(Continued on page 4)

SECTION G. CONTRAST RATING *(Redesigned)*

DEGREE OF CONTRAST		FEATURES											
		LAND/WATER BODY (1)				VEGETATION (2)				STRUCTURES (3)			
		Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)	Strong (3x)	Moderate (2x)	Weak (1x)	None (0x)
ELEMENTS	Form (4x)	12	8	4	0	12	8	4	0	12	8	4	0
	Line (3x)	9	6	3	0	9	6	3	0	9	6	3	0
	Color (2x)	6	4	2	0	6	4	2	0	6	4	2	0
	Texture (1x)	3	2	1	0	3	2	1	0	3	2	1	0
TOTALS		10				10				14			

1a. Maximum element contrast

Moderate

b. Minimum feature contrast

12

2. Does project design meet visual resource management requirements? ☐ Yes ■ No

If "no," request services of district landscape architect, and describe amount of time and when required.

3. Fiscal year	4. Which third? *(check one)*	5. TIME REQUIRED	
		DAYS	MAN-MONTHS
19	☐ First ☐ Second ☐ Third		

SECTION H. RECOMMENDATIONS

1. Recommendation of staff landscape architect if allowable contrast rating cannot be met

Signature	Date

2. Decision and justification of Area or District Manager

Signature	Date

3. Check appropriate box: ☐ Proceed with project/activity as mitigated ☐ Cancel project/activity as proposed

Signature	Date

APPENDIX F

LAND USE CLASSIFICATION AND METHODOLOGY

The scheme selected for analysis and classification of land use is based on an adaptation of the multi-level approach recently developed by the U.S. Geologic Survey for its land use/land cover mapping program (Anderson, et al., 1976: 8-22; Ellis, 1978: 66-101). This multi-level, multi-scale approach is particularly useful for a generalized regional and detailed local approach to land use analysis. The resulting maps and descriptive data are designed to be compatible with the USGS system so that they may later be compared with or incorporated into the USGS land use mapping program as well as being of use to the CDCA Desert Planning Staff.

Sources of data include a series of detailed field mapping site visits, examination of remote sensing imagery (primarily black and while aerial photography at a scale of 1:30,000 flown in 1976, and color infrared aerial photos at a scale of 1:11,000, flown in December 1978), a search of existing documentary and cartographic sources, and contact with local residents and appropriate public and private agencies. Much of the land use data in this study is original or is synthesized for the first time into this form. "Present" land use is divided into the prehistoric (approximately 10,000 BP until 1850) and historic (1850 to 1976) periods; "future" refers to the most-probable use trends after 1980.

Land use categories referred to within the text and tables were determined by first compiling land use documents for similar regions (such as Owens Valley, the northern Mohave area) and determining the types of common land uses and systems for classification. Then a preliminary field reconnaissance of the study region and CGSA was made in October 1978 to consider any additional, unanticipated uses which might then be present. It was discovered that while there was a wide range of land uses, only a few of these were unusual enough to require special consideration (e.g., Military Research, Development Testing and Evaluation; and Historical/Cultural Site Management). On the other hand, a number of other common uses (e.g., timber production and heavy industry) were entirely missing within the study area. It was then decided to map and categorize on the basis of land use only, rather than land cover or land potential; for example, rangeland potentially useful for grazing was only classified as grazing land if actually being used for that purpose. Further, because land use in the region was generally found to be extensive, and not notable intensive (few areas were in fulltime use for any purpose, although such uses often covered enormous surface areas), a scheme of estimating relative intensity was devised, based on the amount of time any given activity or use was taking place during a typical year.

The degree of detail or "scale" of use determination approximates that of Level II of the USGS classification system in order to facilitate the use of aerial photography and to incorporate field checking of predicted results. This also is the most appropriate scale for use with the USGS 15 foot topographic quadrangle maps, the preferred base map scale for maps to be used in the ES. The USGS Level I and Level II schemes are shown below:

Level I	Level II
1 Urban or built up land	11 Residential
	12 Commercial and services
	13 Industrial
	14 Transportation, communications, and utilities
	15 Industrial and commercial complexes
	16 Mixed urban or built-up land
	17 Other urban or built-up land
2 Agricultural land	21 Cropland and pasture
	22 Orchards, groves, vineyards, nurseries, and ornamental horticultural areas
	23 Confined feeding operations
	24 Other agricultural land
3 Rangeland	31 Herbaceous rangeland
	32 Shrub and brush rangeland
	33 Mixed rangeland
4 Forest land	41 Deciduous forest land
	42 Evergreen forest land
	43 Mixed forest land
5 Water	51 Streams and canals
	52 Lakes
	53 Reservoirs
	54 Bays and estuaries
6 Wetland	61 Forested wetland
	62 Nonforested wetland
7 Barren land	71 Dry salt flats
	72 Beaches
	73 Sandy areas other than beaches
	74 Bare exposed rock
	75 Strip mines, quarries, and gravel pits
	76 Transitional areas
	77 Mixed barren land

REFERENCES

Anderson, J.R., et al., "A Land Use and Land Cover Classification System for Use with Remote Sensor Data," USGS Professional Paper 964. Washington: U.S. Government Printing Office, 1976, 28 pp.

Ellis, M.Y. (ed.). Coastal Mapping Handbook. Washington: U.S. Government Printing Office, 1978.

APPENDIX G

ELECTRICITY SUPPLY AND DEMAND

The material in this section evaluates the needs and requirements for the development of geothermal energy, in general, and the Coso Geothermal Resource, in particular.

G.1 Electricity Demand

The last few years have witnessed two developments whose combined effects have been enormous and will continue to be far reaching: (1) energy demand in the USA began to grow much faster than the domestic supply of conventional fuels; and (2) there emerged a political realization that foreign sources of fossil fuels cannot be regarded as ultimately reliable. Awareness of the above developments was acknowledged in a Washington Post editorial which held that "depending upon nine million barrels a day of other people's oil is hazardous to your [economic] health" (Stockman, 1978, 3). More recently, fuel shortages and increased fuel prices have dramatically emphasized the need for greater independence from potentially unreliable foreign sources. The result has been the emergence of a complex nationwide effort (actually a large number of independent efforts) to curb demand and to displace oil imports.

There is a general feeling that market forces acting alone will not have these desired effects and that a major national planning effort is called for. Efforts of this size, however, require massive inputs of information. Most of these informational inputs are actually in the nature of conditional forecasts, made in explicit recognition of a large number of assumptions concerning, for example, (1) economic growth, (2) technological change, and (3) policy evolution. Also, the forecasting methodology must test various alternate sets of assumptions, and thus the forecasts are conditional. Energy planning and decision making without such alternate conditional forecasts is really not possible.

Forecasts of energy supply and demand represent attempts to impose certainty on a sector of the economy characterized by overwhelming complexity and uncertainty. The problem is complicated by the following factors:

1. Interdependence of demands for alternative energy types;
2. Interdependence in the supply response of various energy types;

3. Regulatory policy, just now emerging, with many regulators involved;

4. An unconventional market structure, where supply and demand do not necessarily act jointly to determine a market clearing price and quantity, but where it is often mandated that supply follow demand;

5. The strong influence of foreign cartels, whose actions are not easily forecast; and,

6. The inherent unpredictability of technological advances and fuel reserve additions.

Set against this list of difficulties, as an aid to the forecaster, is a set of empirical regularities which can be presumed to hold in the short and medium term. These are:

1. The strong correlation of California energy supply and demand with USA trends in energy supply and demand.

2. The link between residential energy demand and the size and income of the population served. As is well known, energy consumption has responded positively and in regular fashion to the growth of both population and income. In fact, a combination of two factors--the correlation of electricity demand with population and income, and the generally held view that future price changes will be smaller (as a percent of base) than those that occurred between 1974 and 1977 (California Energy Commission, 1978)--has allowed us to delete the price variable from many energy forecasts. Energy is, in economic terms, a complementary good. Consumers use it in association with energy-consuming durable goods. Yet the stock of such durables owned by consumers, as well as their levels of utilization of this stock, is very much influenced by their income levels. As such, income predicts both of the determinants of a household's consumption of energy. In the short and medium term (where changes in tastes are not substantial) income per household, as well as the number of households, can be expected to predict energy use. This is especially true of the demand for electric energy.

3. A similar line of energy demand with gross domestic product of the state and nation. This demand for energy is actually a derived demand.

4. The fact that we have been able to observe and gather data for a period during which the markets for energy were as markedly changed as in any foreseeable future period.

5. The mandate by regulators that supply plans must be based on anticipated demand levels.

6. The fact that the "inventory" variable is missing from the markets being considered; energy must be produced at about the same time that it is being consumed. Thus, a fairly stable relationship between anticipated peak demand and capacity has emerged over the years. This relationship will change in a predictable way, as the increased use of marginal cost pricing leads to a variable rate schedule which has the effect of smoothing the peaks and shifting some peak demand to periods of excess capacity.

For a number of years prior to 1974, before the beginning of the impacts of the OPEC oil embargo imposed in late 1973 and subsequent OPEC price increases, USA electricity demand grew at an almost constant rate of 7 to 7.5 percent annually. This trend changed abruptly in 1974, with an actual decline in electrical usage during that year; usage is now beginning to increase again (Table G-1). The national trend toward slower electricity growth also holds for California. Annual pre-embargo growth rates were in the 7 to 9 percent range, but since 1974 growth rates have been in the 3 to 5 percent range. Yet most economists feel that while the future growth of consumer electricity demand will not be as high as previously, it will still be substantial, around 4 to 5 percent. This will occur for several reasons:

1. It is doubtful that appeals for voluntary conservation will have as significant an impact now as they had during the oil embargo;

2. The main alternate source (natural gas) will probably eventually become less available or more expensive than electricity; and,

3. Many regulatory policies--such as mandatory conversion of residential and commercial heating to electricity--are pushing consumers away from gas toward electrical power.

TABLE G-1
Projections of Growth Rates of U.S. Electricity Demand

Source	Time Frame	Growth Rate
Exxon(1)	1990	4.5%
General Electric(2)	2000	5.8%
Congressional Research Service(3)	1990	5.0%
Shell Oil Company(4)	1990	5.0%

1. Exxon Corporation, "World Energy Outlook," April, 1978.
2. General Electric Company-TEMPO, Center for Advanced Studies, Ocean Thermal Energy Conversion, Mission Analysis Study, June 1977.
3. Congressional Research Service, U.S. and World Energy Outlook Through 1990, 1977.
4. Shell Oil Company, The National Energy Outlook, 1980-1990, July 1978.

The cutoff of Iranian oil supplies and subsequent increase in OPEC oil prices that occurred during the first seven months of 1979 may reduce the long term US electricity growth rate below the projected 4 to 5 percent per annum. The reduction in demand, however, should be small since: 1) oil is one of many sources for generating electrical power; 2) the substitutes for electrical power are generally oil and natural gas, both of which are being deregulated; (3) the use of oil and natural gas to produce electricity is mandated to be phased out by 1990 by the Power Plant and Industrial Fuels Act of 1978 (part of the 1978 Federal energy legislation). In response to the short term oil shortage, President Carter has implemented the Emergency Building Temperature Restrictions, Energy Conservation Contingency Plan No. 2. The provisions of the Plan became effective July 16, 1979, and require that commercial, industrial, and other non-residential buildings be cooled to no lower than 78 degrees Fahrenheit and heated to no more than 65 degrees Fahrenheit.

The California electricity demand (sales) forecast prepared for the Coso Geothermal Development Model was developed from data submitted by Pacific Gas and Electric Company (PG&E) and Southern California Edison Company (SCE) to the California Energy Commission (CEC). These documents were submitted in accordance with the California Energy Commission's Common Forecasting Methodology II (CFM II) reporting requirements. CFM II is a general reporting format established by the CEC for ease of comparison. It incorporates a common demographic base, which CEC furnishes to the utilities for use in preparing their forecasts. CFM II is thus designed to yield consistent forecasts from the utilities in order to assist the Energy Commission in planning a statewide electrical system.

Since the CFM II documents contain both the actual data for the past eight years for PG&E and the past 17 years for SCE, as well as the forecasts of the dependent variables (population, income, real gross state product) through 1998, the CFM II submittals were used as the basis for the statistical analysis and for the electricty demand projections. The exact nature of the data used in this report is discussed in the following sections on residential and commercial/industrial estimates. The estimated equations and their summary statistics are contained in Table G-2.

TABLE G-2

Estimating Equations

PG&E Service Area

Residential

Gigawatt hours=-31,999 + 5.28(population)

R = 0.9r t = 10.8

Commercial

Gigawatt hours = -12,494 + 461.73 (RGSP) - 2690*

R = 0.97 t = 8.9

*Dummy variable: 0 for years 1970-1976, 1 for 1977

SCE Service Area

Residential

Gigawatt hours = -29231 + 3.41 (Population) + 1.27(Customer Income)

R = 0.97 t = 4.62

Commercial/Industrial

Gigawatt hours = -12,904 + 463.62 (RGSP)

R = 0.91 t = 9.8

Residential Estimates - The demand for electricity by residential users was assumed by ERG to depend on the service area population and the average service area family or customer income. For the SCE service area, annual electricity sales for the years 1961 to 1977 were regressed with SCE service area population and customer income. The estimated coefficients for population (3.41) and income (1.24) represent the average consumption of electricity (in gigawatt hours) per thousand people and per dollar of customer (family) income. The coefficients of both dependent variables (population and income) were statistically significant (t greater than 2) and were used to forecast electrical sales (Table G-3). Annual electricity sales for the PG&E

service area were also regressed on service area population and customer income. The estimated coefficient for population was statistically significant; however, the coefficient for customer income was not significant. The equation was estimated a second time, with per capita income substituted for customer income, but the income coefficient was still not statistically significant (negative coefficient and t statistic approximately 1). The future projections of residential electricity sales in the PG&E service area (Table F-3) were, therefore, based only on the population forecasts. The equation presented in Table F-2 for the PG&E residential service area is the estimated equation using only population as the dependent variable.

The population forecasts used to project future electricity sales are based upon California Department of Finance Series E-150 population estimates. Series E-150 population estimates assume replacement fertility (2.11 births per woman in her lifetime) and net inmigration to California of 150,000 people per year. The SCE forecast of customer income assumes increases at a real annual rate of 2.3 percent and reflects the increased role of women in the labor force.

Commercial/Industrial Estimates - The demand for electricity by commercial/industrial users was assumed to depend only on the level of Real Gross State Product (RGSP). Prices of electricity, natural gas, and other fuels were not included because the forecast future price increases were much less than the price increases that occurred in the period 1974-1978. Secondly, the price of electricity is significantly greater than the price of gas or other alternative fuels (by a factor of two for large energy users), so that small changes in the price of electricity vs changes in the price of gas and other alternative fuels should not result in significant changes in demand for electricity.

Commercial/industrial annual electricity sales were regressed with RGSP for the years 1965-1977 for the SCE service area and 1970-1977 for the PG&E service area. A dummy variable was used in the PG&E equation in order to capture the effect of PG&E's substantial price increase in 1977. This was not necessary in the SCE equation, since SCE's overall price increase was smaller and was phased in over the 1974-1977 period. The coefficient for RGSP was statistically significant in both equations and was, therefore, used to forecast future electricity demands by commercial/industrial users (Table F-3). The estimated RGSP coefficients for the SCE service area (463.63) and the PG&E service area (461.73) represent the average commercial/industrial usage for each billion dollars of real gross state product. The forecast of future RGSP was obtained for the Technical Supplement (Appendix E) to the Southern California Edison CFM II submission. In this forecast, RGSP is expected to grow at an annual rate of 3.3 percent, almost a full percent less than the 1960-1973 growth rate of 4.2 percent.

TABLE F-3
Projection of Electricity Sales by PG&E and SCE
1977-1995 (Gigawatt-hours)

	1977 ACTUAL	1980 PROJECTED	1985 PROJECTED	1990 PROJECTED	1995 PROJECTED
PG&E SERVICE AREA					
Residential	17,333	20,110	24,260	28,460	32,360
Commercial/ Industrial	29,051	35,420	45,260	55,280	66,080
TOTAL	46,384	55,530	69,520	83,740	98,440
SCE SERVICE AREA					
Residential	14,286	17,100	21,360	25,420	29,460
Commercial/ Industrial	29,781	37,910	47,780	57,840	68,690
TOTAL	44,067	55,010	69,140	83,260	98,150
TOTAL for Both Service Areas	90,451	110,540	138,660	167,000	196,590

ANNUAL GROWTH RATE 1977-1995 4.4%

California Demand Projection - Once the future residential and commercial/industrial electricity demands were projected (Table F-3), they were summed to obtain service area projections and added together to obtain a total for both service areas. The projections for the electricity demand in the two service areas are used as a proxy for determining the statewide growth rate in electrical demand. In other words, the growth rate associated with the 1977 to 1995 electrical demand projection for the PG&E and SCE services area is used as the basis for projecting the growth in California electricity demand.

The projected annual growth rate of electrical sales to 1995 for PG<E and SCE service areas is 4.4 percent. This rate was reduced to 4.1 percent in order to reflect the significantly lower growth rates of electricity purchasing sectors that are not included in this model; agricultural sales and sales of electricty to other utilities outside California, for example, are expected to grow at a much lower rate or to decline through 1995. The 4.1 percent annual growth rate was then applied to actual California electricity sales in 1977 in order to project the total California electricity demand (sales) to 1995

(Table G-4).

TABLE G-4
Projection of California Electricity Demand: 1977-1995

Year	Electricity Demand (Gigawatt Hours)
1977	163,125
1980	184,000
1985	225,000
1990	275,000
1995	336,000

The projections for PG&E and SCE together as a percentage of total California sales (between 75 and 80 percent of statewide sales) are expected to remain stable through 1995. San Diego Gas and Electric (SDG&E) and Los Angeles Department of Water and Power (LADWP) are the other major utilities in the state. SDG&E demand (6.0 percent) is expected to grow somewhat faster than SCE and PG&E (3.8 percent), while LADWP demand (3.1 percent) is expected to grow somewhat slower, based on the CFM II submittals of these utilities to the CEC.

Table G-5 provides a comparison of this forecast with several other forecasts of future electricity demand. Our forecast growth for California is somewhat higher than the growth rates projected by the California Energy Commission (CEC) and the electric utilities, but lower than rates given in other consultant reports. It was anticipated that this predicted growth rate would be somewhat greater than rates forecast by CEC and the electric utilities. The forecasting methodologies used by these groups are more complex than the

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TABLE G-5
Forecasted Growth Rates for Electricity Demand

Source	Time Frame	Growth Rate
ERG Forecast	To 1995	4.1%
California Energy Commission (1)	1995	
State		3.8%
PG&E		3.4%
SCE		3.8%
Southern California Edison (2)	To 1998	3.8%
Pacific Gas and Electric (3)	To 1998	3.8%
California Public Utilities Commission/Port of Long Beach (4)	1985	4.5-5.0%
Nuclear Regulatory Commission (5)	1985	4.5%

1. California Energy Commission, California Energy Trends and Choices, 1977
2. Southern California Edison Co., Common Forecasting Methodology II, Demand Forecast, March, 1978, Submitted to the California Energy Commission.
3. Pacific Gas and Electric Co., Common Forecasting Methodology II, Demand Forecast, February, 1978, Submitted to the California Energy Commission.
4. California Public Utilities Commission/Port of Long Beach, EIR for the SOHIO West Coast to Mid-continent Pipeline Project, 1976, Volume III.
5. Nuclear Regulatory Commission, DES for the Sundesert Nuclear Plants, Units 1 and 2, January, 1978.

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methodology used in this report. Savings from load management techniques and additional conservation measures are already included in our forecast, since load management techniques and additional non-price conservation measures are responses to anticipated demands by utilities and regulators in order to reduce the need for new capacity by transferring demand from peakload times to other hours.

As noted earlier, utility supply plans are based upon the anticipated level of peak demand in the future. Since there has been a stable past relationship between peak demands (not adjusted for load management or conservation savings) and total sales, the future capacity requirements can be forecast based on projected future sales. We have forecast that peak demands, hence capacity requirements, will grow at 4.1 percent per year. Table G-6 shows the projected

TABLE G-6
Projection of California Peak Demands and Required Capacity
1977-1995 (MW)

Year	Projected Peak Demand	Required Capacity (18% Margin)	Additional Capacity Required (1977 Base)
1977	30,610	37,858	------
1980	34,400	40,600	2,742
1985	41,900	49,400	11,542
1990	51,000	60,200	22,342
1995	62,000	73,200	35,342

statewide peak demands and the capacity required to meet these demands as well as additional capacity required, using 1977 as a base year. It has been assumed that utilities will maintain an 18 percent margin (statewide) above anticipated peak demands as a protection against power outages due to system overload at peak periods. The forecasts of required capacity should, therefore, be viewed as a potential upper bound for required capacity. Some utilities may utilize a lower reserve margin than 18 percent. Further, peak demands are not experienced by all utilities at the same time. California has a summer-peaking electrical demand, but, due to differing climates and mixes of users, the highest peak demand recorded during the year for each utility does not occur on the same day, although the day-to-day peaking requirements are similar. Finally, load management savings are not included in the forecast. Load management is a response to the differential between-peak and off-peak demands. It is a means of lowering peak demand, and thus lowering required capacity. The implication of the forecast presented in Table G-6 is that utility capacity will need to almost double by 1995.

Some of the increased capacity can be acquired through the formulation of better load management techniques and better conservation practices. However, a large portion of the increase in capacity will come from new generating facilities. The exact composition of the new capacity (by generating types) is still open to conjecture; but, since the increases in required capacity are a response to anticipated demands, the exact composition of the new capacity will have little impact on the overall forecast level of demand. The type of additional capacity utilities will install will depend upon costs, environmental questions, permit and political questions, and a desire to have a broad mix of generating types. Geothermal, nuclear, coal, oil, and solar power generating systems can be seen both as competing for a part of the new capacity and working together to provide a diversified generating base.

G.2 Energy Supply

In 1977, California electrical demands were satisfied with electricity generated from natural gas (25 percent), and coal (10 percent), oil (46 percent), nuclear (6 percent), geothermal (5 percent), and hydroelectric (7 percent). Only 83 percent of the electricity used in California is generated in California. The remaining 17 percent, including all of the coal-produced electricity and one-half of the hydroelectric power, is generated out of state (California Energy Commission, 1979). This represents a significant change from 1960, when nearly all of California's electricity needs were supplied from within the state. Electricity was generated primarily by natural gas (61 percent) with oil (27 percent) and hydropower (12 percent) generating the remainder of California's electricity needs (California Energy Commission, 1979). The shift in California electricity production away from natural gas since 1960 is the result of decreasing availability of natural gas and the availability of new generating systems (primarily nuclear and geothermal). California's dependence on oil- and gas-generated electricity must be phased out by 1990 (the year 2000 under certain conditions) given the mandates of the Power Plant and Industrial Fuels Act of 1978.

The only commercially operating geothermal field in the United States is The Geysers, located in Northern California. The Geysers field is characterized as a vapor-dominated (dry steam) field; that is, the geothermal working fluid reaches the surface as steam. The advantages of a vapor-dominated field as opposed to a liquid-dominated field (the probable characteristics of the Coso KGRA) are twofold:

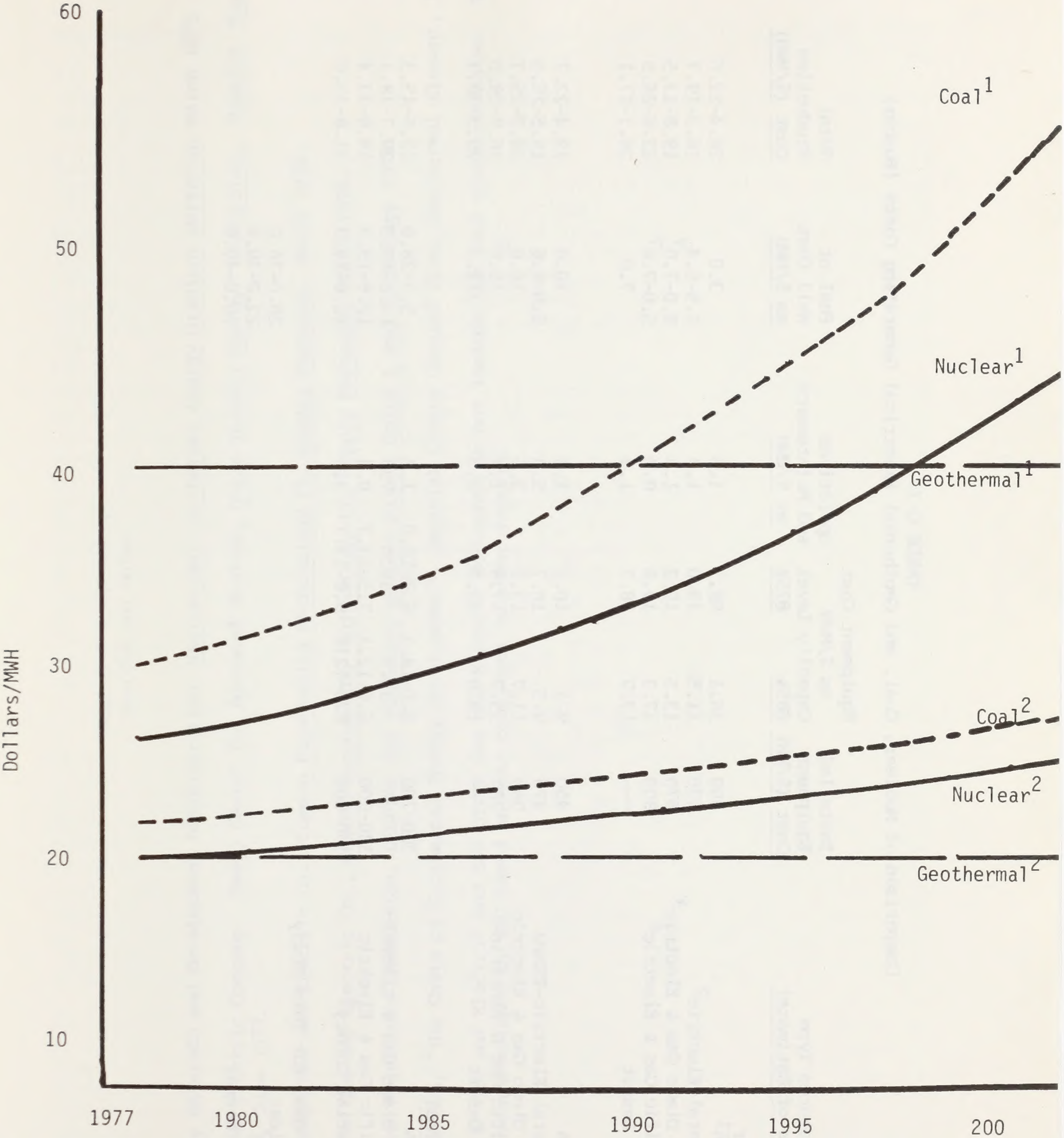
1. The technology to make use of dry steam currently exists, and has for some time; and,

2. The fluid dominated resource is more corrosive than is the steam dominated resource.

The technology required for the commercialization of liquid dominated geothermal resources is still in the demonstration plant stage. Because of the uncertainty associated with the commercial operation of liquid dominated geothermal resources, the projections for the costs of electricity produced by such resources show a great deal of variation.

Clearly, geothermal electricity must be cost competitive with coal and nuclear facilities as a baseload resource before geothermal production becomes an acceptable alternative for utilities to consider. At the present time, vapor dominated geothermal resources, such as The Geysers, are cost competitive (less than $20/MWH) with nuclear and coal facilities. However, the economic aspect of geothermal electricity production is not the only condition that will affect its viability as an energy source. Planning and land use restrictions, preference for renewable versus non-renewable energy sources, and preference for domestic versus imported energy are several factors that will affect the future of geothermal electricity in competition with coal, nuclear, hydro or solar electricity.

We have examined a number of sources of electricity in order to develop a range of probable costs for nuclear, coal, and geothermal production of electricity (Table G-7). These estimates seem to represent a good range of the low and high costs of generating electricity in California. Estimates were not prepared for hydroelectric production because it is not currently viewed as an expandable resource for the future. Estimates were also not prepared for gas or oil fired generating facilities since it is probable that such facilities will be phased out as baseload power sources. They will, however, very probably still serve as power sources for intermediate and peakloads. Solar and wind electrical power were not examined because they are also at the development stage. The lower bound estimate for coal fired power plants (Figure G-1 and



1 = High-Range Projection
2 = Low-Range Projection

Assumes minimum 3% and maximum 6% real annual increase in the price of coal and nuclear fuel.

Figure G-1. Projected Electricity Costs: 1980-2000

TABLE G-7

Comparison of Nuclear, Coal, and Geothermal Electrical Generating Costs (Busbar)

Resource Type (Source of Estimate)	Installed Equipment Cost ($/KW)	Equipment Cost as $/MWH Capacity Level @85%	Equipment Cost as $/MWH Capacity Level @75%	Operations and Maintenance as $/MWH	Fuel or Well Cost as $/MWH	Total Production Cost ($/MWH)
Nuclear						
ERDA[1]	800	16.1	88.3	1.3	3.0	20.4-22.6
General Electric[2]	570	11.5	13.0	1.3	3.5-5.4	16.3-19.7
San Diego Gas & Electric[3]	670	13.5	15.2	1.3	5.0-7.0[7]	19.8-23.5
Pacific Gas & Electric[4]	800	17.3	19.6	0.3	5.0-7.0[7]	22.6-26.9
Sun Desert	---	17.7	18.7	1.4	7.0	26.1-27.1
Coal						
ERDA	450	9.1	10.2	1.3	10.0	19.4-22.7
General Electric-TEMPO	470	9.5	10.7	5.0	5.0-9.8	19.5-26.0
San Diego Gas & Electric	580	11.7	13.2	2.5	10.0	24.2-25.7
Pacific Gas & Electric	781	15.7	17.8	1.2	10.0[7]	26.9-29.0
Sun Desert	---	14.8	15.8	2.2	12.3	29.3-30.3
Geothermal						
ERDA	300-700	6.0-14.1	6.8-16.0	1.3	5.3-28.0	12.6-45.3
San Diego Gas & Electric	700	14.1	16.0	2.8	12.8-19.3[7]	29.7-38.1
Pacific Gas & Electric	330-600	6.6-12.1	7.5-13.7	0.4	12.8-19.3	19.8-33.4
Imperial County[6]	300-600	6.0-12.1	6.8-13.7	3.6	12.8-19.3	21.8-39.0
Ranges Used for This Study						
Nuclear					20.0-26.0	
Coal					22.0-30.0	
Geothermal					20.0-40.0	

TABLE G-7 (CONTINUED)
Sources and Notes

1. Energy REserach and Development Administration, Near-Normal Geothermal Energy Gradient Workshop, March 1975

2. General Electric Company - Tempo Center for Advanced Studies, Ocean Thermal Energy Conversion, Mission Purpose Study, June 1977.

3. San Diego Gas and Electric Co., Common Forecasting Methodology II, Supply Forecast, April 1978.

4. Pacific Gas and Electric Co., Common Forecasting Methodology II, Supply Forecast, April 1978.

5. Nuclear Regulatory Commission, DES for the Sundesert Nuclear Plant, Units 1 and 2, January 1978.

6. Tod Larson, "The Costs of Geothermal Energy Development", Imperial County General Plan, Geothermal Element, 1976.

7. Pacific Gas and Electric and San Diego Gas and Electric documents do not include the fuel costs estimates. These have been developed by ERG based on data contained in other reports.

Table G-7) may possibly underestimate the costs of emission control equipment required to meet California's more stringent emission requirements.

In preparing these estimates, it was assumed that there will be no real increase (constant dollars) in the capital or operating costs of coal, nuclear or geothermal facilities. While this assumption is simplistic, it has merit. Many of the components used for electrical generation are common to all three facilities, and increases in costs for the components should affect each type of facility equally. In addition, if there are real price increases (in constant dollars) and these increases affect each facility equally, the increase could be factored out to return the cost estimates to the original relative cost relationship. The cost estimates have not included, however, potential new regulatory constraints on coal, nuclear or geothermal facilities; such new mandates may significantly affect the relative costs of these facilities.

Fuel prices have been allowed to vary in these estimates. It was assumed that the real price of geothermal steam will remain constant over time, reflecting the fact that geothermal resources are not expected to be characterized by increasing scarcity as are coal and nuclear fuels. The "low-price" scenario anticipates a 3 percent annual real increase in the price of fuel, while the "high-price" scenario reflects the current trend in the prices incorporated in long-term nuclear and coal contracts (Washom, 1977). The effects of the 3 percent and 6 percent increases in the price of fuel upon the annualized fuel cost (a calculated fuel cost that takes into account future price increases) are shown in Table G-8.

TABLE G-8
Fuel Price Scenarios

	Nuclear		Coal	
Year	3% Real Escalation ($/MWH)	6%Real Escalation ($/MWH)	3%Real Escalation ($/MWH)	6%Real Escalation ($/MWH)
1977	5.0	7.0	5.0	10.0
1980	5.5	8.3	5.5	11.9
1985	6.3	11.2	6.3	15.9
1990	7.3	14.9	7.3	21.3
1995	8.5	20.0	8.5	28.5
2000	9.8	26.7	9.8	38.2

TABLE G-9
Busbar Electricity Fuel Cost Scenarios
(Fuel Cost Escalation)

	Nuclear		Coal	
Year	3% $/MWH	6% $/MWH	3% $/MWH	6% $/MWH
1977	20.0	26.0	22.0	30.0
1980	20.5	27.3	22.5	31.9
1985	21.3	30.2	23.3	35.9
1990	22.3	33.9	24.3	41.3
1995	23.5	39.0	25.5	48.5
2000	24.8	45.7	26.8	58.2

Table G-9 displays the busbar electricity costs for nuclear and coal power plants that are currently projected to come on line in the years 1980-2000. (The levelized busbar energy cost is the price per unit of energy (dollars/MWH) which, if held constant through the life of the system, would provide enough revenue to equal expenses.) Figure F-1 displays the busbar costs of electricity for all three types of facilities through the year 2000. This figure clearly shows the uncertainty (with regard to costs) that clouds the development future of geothermal electricity production. While vapor-dominated geothermal sources similar to the The Geysers are among the cheapest of fuel sources, the potentially high development cost of liquid-dominated "brine" fields puts the high range for geothermal development at one-third above the high cost estimate for coal. Under the "high-cost" assumptions for all three facilities, the cost of geothermal electricity is competitive with coal by 1989 and competitive with nuclear power by 1996. It must be remembered, however, that the economic costs alone do not address uncertainties in future policy considerations. Federal, state, and local regulations regarding land use restrictions, use of renewable versus non-renewable fuel sources, nuclear waste disposal or pollutant emissions could have substantial impacts on the viability of any one of these electrical power sources. The development of geothermal resources at Coso Hot Springs, as a means of providing a portion of statewide electric generating capacity requirements, will depend upon the future regulatory climate as well as the estimated cost of future electrical production.

Another factor that must be considered in the development of the Coso Geothermal resources is the means of transporting the electricity produced at Coso to consumers. The attractiveness of a potential power plant site is diminished if the site location will require the construction of extensive new transmission facilities. Such construction increases the capital cost of installed capacity without increasing that capacity. The Coso Geothermal

Resource area is near a major transmission corridor. Southern California Edison (SCE) and Los Angeles Department of Water and Power (LADWP) jointly own an 800 kilovolt (KV) direct current (DC) transmission line which passes through Rose Valley. This transmission line is part of the Western States Intertie and is used to transport electrical energy between the State of Washington and Southern California (Schroder, 1978). DWP and SCE also have 230 KV and 115 KV alternating current lines, respectively, that run through the area. These lines supply electrical power to the surrounding region and to other parts of Southern California. Electrical power that might be developed at Coso can conceivably be added to either network.

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Mr. W.E. Schroder, Chief Transmission Engineer, Southern California Edison Company, October 1978.

APPENDIX H

GLOSSARY OF TERMS

AESTIUATE: Pass the summer in a dormant condition.

AEROSOL: A suspension of small particles in the atmosphere.

ALLUVIAL FAN; The land counterpart of a delta. It is composed of sediments deposited as a stream flows from steeper mountains to flatter valleys.

ALLUVIAL VALLEY: A valley filled with alluvium (see "alluvium").

ALLUVIUM; A general term for unconsolidated rock particles deposited during recent geologic time by running water as a sediment in the bed of a stream or on its flood plain or delta, or as a cone or fan at the base of a mountain slope.

ANNULUS; The space between the casing and the wall of a drill hole.

AQUIFER: A permeable material through which ground water moves. A water-bearing formation.

ATMOSPHERIC LAPSE RATE: Rate of change of temperature as a function of elevation.

AUM: Animal unit month; measure of grazing capacity used by managers of range land.

AXIAL LOADS: Compressional forces acting on a rock mass.

A-WEIGHTED DECIBEL SCALE (dBA): Noise level weighted to human perception.

BACKGROUND: The area of a distance zone which lies beyond the foreground-middleground. Usually from a minimum of 3 to 5 miles to a maximum of about 15 miles from a travel route, use area, or other observer position. Atmospheric conditions in some areas may limit the maximum to about 8 miles or increase it beyond 15 miles.

BASALT: A fine-grained, dark colored, igneous rock composed chiefly of calcic plagioclase feldspar, magnesium and iron-rich silicates. The extrusive equivalent of grabbo.

BASEMENT ROCK: The crust of the earth below sedimentary deposits extending downward to the Mohorovicic discontinuity.

BASIC ELEMENTS: The four major elements (form, line, color, and texture) which determine how the character of a landscape is perceived.

BASIN AND RANGE: A physiographic province characterized by a series of tilted fault blocks forming long, asymmetric ridges or mountains and broad, intervening valleys.

BATHOLITH: A large, igneous rock mass that has more than 40 sq. mi (100 km^2) in surface exposure, increases in size downward, and has no determinable floor.

BEDROCK: A general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material.

BEDROCK ACCELERATION: Accelerations induced in bedrock resulting from earthquake energy release.

BIVOUACS: An encampment under little or no shelter, usually for a short time.

BLOWOUT: An uncontrolled, accidental release of geothermal fluid and gases from a geothermal well.

BRECCIA: A rock composed of angular and broken rock fragments cemented together in a finer-grained matrix.

CALDERA: A large, basin-shaped, volcanic depression, more or less circular in form.

CARAPACE;: A hard, protective outer covering.

CENOZOIC: The most recent era of geologic time. It consists of two periods, the Quaternary, which began about 1.5 to 2 million years ago, and the Tertiary, which began about 65 million years ago.

CHARACTERISTIC: A distinguishing trait, feature, or quality.

CLASTIC: A rock or sediment composed principally of broken fragments that are derived from pre-existing rocks or minerals and that have been transported individually from their place of origin.

COEFFICIENT OF STORAGE: For an aquifer, the volume of water released from storge in a vertical column of 1.0 sq. ft. when the water table or other piezometric surface declines 1.0 ft. In an unconfined aquifer, it is approximately equal to the specific yield.

COEFFICIENT OF TRANSMISSIVITY: In an aquifer, the rate at which water of the prevailing kinematic viscosity is transmitted through a unit width under a unit hydraulic gradient; also embodies the saturated thickness and properties of the contained liquid.

COLOR: The property of reflecting light of a particular wavelength that enables the eye to differentiate otherwise unidentifiable objects.

CONGLOMERATE: A coarse-grained, clastic sedimentary rock composed of rounded to subangular fragments larger than 2 mm in diameter set in a fine-grained matrix.

CONTRAST: The effect of a striking difference in the form, line, color, or texture of the landscape features within the area being viewed.

CONTRAST RATING: A method of determining the extent of visual impact for an existing or proposed activity that will modify any landscape feature (land and water form, vegetation, and structures).

CRITICAL VIEWPOINT: The point(s) commonly in use or potentially in use where the view of a management activity is the most disclosing.

CRUSTAL EXTENSION: Differential movement between two blocks of crustal material. This most often occurs along the active faults of continental or oceanic plate boundaries.

CULTURAL MODIFICATION: Any man-caused change in the land or water form or vegetation or the addition of a structure which creates a visual contrast in the basic elements (form, line, color, texture) of the naturalistic character of a landscape.

dBA: Logarithmic noise scale weighted to the response of the human ear.

DESERT PAVEMENT: A thin, smooth, or sheet-like, residual concentration of wind-polished, closely packed pebbles, boulders, gravel, and other rock fragments, mantling a desert surface. Wind action and sheetwash remove all smaller particles (sand and dust) which leaves a protective covering of larger material over the underlying fine-grained soil.

DISCHARGE: The rate of flow (of water) at a given moment in time, expressed as a volume per unit of time.

DISSECTION: The process of erosion whereby the continuity of a relatively even topographic surface is gradually sculptured or destroyed by the formation of gullies, ravines, canyons or other kinds of valleys.

DISTANCE ZONE: The area that can be seen as foreground-middleground, background, or seldom-seen.

DOME: (a) a large igenous intrusion whose surface is convex upward with the sides sloping away at low but gradually increasing angles; (b) an uplift or anticlinal with circular outline, in which rock dips gently away in all directions.

DOMINANT ELEMENTS: The basic elements (form, line, color, texture) in a particular landscape which exert the greatest influence on the visual character of the landscape.

DOWN-GRADIENT: See Hydraulic Gradient.

DRAINAGE BASIN: The whole area or tract of land that gathers water originating as precipitation and contributes it ultimately to a particular stream channel, lake, reservoir, or other body of water.

DRILLING DUMP: A slush pit dug specifically for the disposal of drilling mud and cuttings produced during drilling.

ECOSYSTEM: A system formed by a community of organisms (plants and animals) in interaction with their total environment.

ELECTRODIALYSIS: A method of separating compounds in solution by their differing rates of diffusion through a semipermeable membrane. This process is assisted by the application of an electromotive force to electrodes adjacent to the semipermeable membranes.

ENDEMIC: Restricted to a particular locality.

EN ECHELON: Geologic features that are in an overlapping, staggered or step-like arrangement, e.g., faults. Each segment is relatively short but collectively they form a linear zone.

EPICENTER: That point on the earth's surface which is directly above the focus of an earthquake.

EVAPOTRANSPIRATION: Loss of water from a land area through transpiration of plants and evaporation from land and water surfaces.

EXTRUSIVE: An igneous rock that has been ejected from molten rock material and solidified on the surface of the earth. Extrusive rocks include lava flows and detrital material such as volcanic ash. They generally are fine-grained.

FANGLOMERATE: A sedimentary rock consisting of slightly water-warn heterogeneous rock fragments of all sizes, originally deposited in an alluvial fan and cemented into a firm rock.

FAULT: A surface or zone of rock fracture along which there has been displacement, from a few centimeters to hundreds of kilometers in scale. Faults are classified according to the relative motion of the rock on each side of the fracture zone or fault plane. These classifications are illustrated in the Technical Report.

FAULT BLOCK MOUNTAINS: Mountains bounded on at least two opposite sides by faults.

FAULT ZONE: A fault that is expressed as a zone of numerous small fractures, or of breccia or fault gouge. A fault zone may be a few meters to a few kilometers wide.

FAUNA: The animals or wildlife of a given region; used as a singular (plural: faunas or faunae); also a study decribing that wildlife.

FERAL: Having reverted to the wild state (formerly domesticated, for example).

FLORA: The plants of a given region (plural: floras or florae); also a study describing those plants.

FOCUS (of an earthquake): That point within the earth which is the center of energy release of an earthquake and the origin of its elastic waves.

FOREGROUND-MIDDLEGROUND: The area visible from a travel route, use area, or other observer position to a distance of 3 to 5 miles. The outer boundary of this zone is defined as the point where the texture and form of individual plants are no longer apparent in the landscape. Vegetation is apparent only in patterns or outline.

FORM: The mass or shape of an object or objects which appear unified, such as in the shape of the land surface or patterns placed on the landscape.

FROST HEAVING: The uneven lifting or upward movement, and general distortion, of surface soils, rocks, vegetation, and other structures, resulting from expansion due to freezing of water and growth of ice masses within other materials.

FUGITIVE DUST: Dust resulting from a non-localized emission source such as automobile traffic on unpaved roads or wind erosion of exposed areas.

FUMAROLES: A volcanic vent from which gases and vapors are emitted; it is characteristic of a late stage of volcanic activity.

GABBRO: A coarse-grained, igneous rock with the composition of basalt.

GEOLOGIC TIME: A chronological sequence of earth time. It is divided into four eras--the Precambrian, more than 570 million years go (mya); the Paleozoic, from 225 to 570 million mya; the Mesozoic, from 65 to 225 mya; and the Cenozoic, from the present to 65 mya.

GEOPHYSICS: The study of the earth by quantitative physical methods, especially by seismic reflection and refraction, gravity, magnetic, electrical and radiation methods.

GRADIENT HOLES (temperature): Holes that are drilled and constructed specifically to measure thermal gradients beneath the earth's surface.

GRANITE: A coarse-grained, intrusive igneous rock consisting essentially of light colored minerals, including feldspars and quartz.

GRANODIORITE; A coarse-grained, intrusive igneous rock intermediate in composition between granite and diorite.

GRAVITY SURVEY: Measurements of the gravitational field at a series of different locations. The objective in exploration is to associate variations in the gravity field with differences in the distribution of densities, and hence of rock types.

GROUND WATER BASIN: An area underlain by water-bearing materials capable of storing and yielding a ground water supply. In most cases, these materials would consist of unconsolidated or consolidated sediments, or a sedimentary reservoir.

HABITAT: The environment that is natural for the life and growth of a plant or animal.

HEAT FLOW: Dissipation of heat from within the earth by conduction, convection or radiation at the surface.

HEAT FLOW UNIT (HFU): A measurement of terrestrial heat flow equivalent to 10^{-6} cal/cm^2/sec.

HERPETOFAUNA: Reptiles and ambphibians.

HOLOCENE: An epoch of the Quaternary period, from the end of the Pleistocene (1.5 to 2 million years go) to the present.

HORST AND GRABEN STRUCTURES: An elongate, relatively depressed crustal unit that is bounded on both sides by faults (usually normal).

HYDRAULIC GRADIENT: In an aquifer, the rate of change of pressure head (height of a column of water that the pressure can support) per unit of distance of flow at a given point and in a given direction. It is usually expressed in meters per kilometer or feet per mile.

HYDROFRACTURING: Fracturing induced in rocks beneath the surface by injection of fluids at high pressures into drill holes.

HYDROLOGIC BUDGET: An accounting of the inflow to outflow from, and storage in, a hydraulic unit, e.g., drainage basin, aquifer or reservoir; the relationship between evaporation, precipitation, runoff and change in water storage is implied.

HYDROLOGIC STUDY AREA: The area enclosed by the watershed boundaries of Rose Valley, Coso Valley and Coso Basin and several smaller enclosed basins between Rose Valley and Coso Basin.

HYDROTHERMAL: Pertaining to heated water (or aqueous solution) or products resulting from heated water, i.e., alteration of rocks or minerals by reaction of hydrothermal water.

INTERBEDDED: Sedimentary rock layers laid between or alternating with others of different character.

INTERCEPTION: The process by which water falls on plant surfaces and is evaporated back into the atmosphere without reaching the ground surface.

INTRUSION: A feature (land and water form, vegetation, or structure) which is generally considered out of context because of excessive contrast and disharmony with the characteristics landscape.

INTRUSIVE: An igneous rock that has cooled, from magma, beneath the earth's surface. It is generally coarse-grained.

ION EXCHANGE: A chemical reaction involving the reversible replacement of certain ions by others, without loss of crystal structure.

KEY OBSERVER POSITION (KOP): One or a series of observer positions on a travel route or at a use area or a potential use area, that are used to determine seen area.

LACUSTRINE SEDIMENTARY: A sediment pertaining to, produced by, or formed in a lake or lakes.

LANDFORM: A term used to describe the many types of land surfaces which exist as the result of geologic activity and weathering, e.g., plateaus, mountains, plains, and valleys.

LAND PATENT: Title to land from a government agency, obtained through filing of a claim establishing productive occupancy of the land resource.

LAND CHARACTER: The arrangement of a particular landscape as formed by the variety and intensity of the landscape features and the four basic elements of form, line, color, and texture. These factors give the area a distinctive quality which distinguishes it from its immediate surroundings.

LANDSCAPE FEATURES: The land and water form, vegetation, and structures which compose the characteristic landscape.

LANDSCAPE MODIFYING ACTIVITIES: Any actions which change the land and water form or vegetation or places structures on the landscape.

L_{eq}: Measure of average decibel level.

L_{dn}, CNEL: Measures of average decibel level, weighted more heavily in the night and evening.

L_x: Sound decible level which is exceeded X percent of the time.

LINE: The path, real or imagined, that the eye follows when perceiving abrupt differences in form, color or texture. Within landscapes, lines may be found as ridges, skylines, structures, changes in vegetative types, or individual trees and branches.

LIQUEFACTION: The sudden large decrease of the shearing resistance of a cohesionless soil, caused by a collapse of the structure by shock or strain, and associated with a sudden but temporary increase of the pore fluid pressure. It involves a temporary transformation of the material into a fluid mass.

LITHOLOGIC: Description of rocks, especially sedimentary clastic hard speciment and in outcrop, on the basis of color, structure, mineralogic composition and grain size.

L_x: Decibel level which is exceed X percent of the time.

MAGMATIC WATER: Water contained in or expelled from magma.

MAGNITUDE (earthquake): A measure of the strength of an earthquake or the strain energy released by it, as determined by seismographic observation.

MELT: A liquid, fused rock.

METAMORPHIC ROCK: Includes all those rocks which have formed in the solid state in response to pronounced changes of temperature, pressure and chemical environment, which take place in general below the shells of weathering and cementation.

METASEDIMENTS: (a) A sediment or sedimentary rock which shows evidence of having been subjected to low-grade metamorphism; (b) a metamorphic rock of sedimentary origin.

METAVOLCANICS: See Metasediments.

MICROCLIMATIC VARIABLES: Localized climate parameters.

MICROSEISMIC DATA: Data on small earthquakes, or ground motions, which are detectable only with sensitive instruments.

MODIFICATION: To reduce in degree or diminish in harshness the degree of visual contrast of a cultural intrusion or improvement.

MODIFIED MERCALLI INTENSITY: One of the earthquake intensity scales based on human's perceptions of earth motions. It has 12 divisions ranging from I, which is barely perceptible to trained observers at rest to XII, which represents total destruction.

MUD POT: A type of hot spring containing boiling mud, usually sulfurous and often multicolored. Commonly associated with geysers and other hot springs in volcanic areas.

NATIONAL REGISTER OF HISTORIC PLACES: The official list, established by the Historic Preservation Act of 1966, of the nation's cultural resources worthy of preservation. The Register lists archaeological, historic, and architectural properties (i.e., districts, sites, buildings, structures, and objects) nominated for their local, state or national significance by state and/or Federal agencies and approved by the National Register staff. The list is maintained by the U.S. Department of the Interior, National Park Service, with special responsibilities delegated to State Historic Preservation Officers (SHPOs) to develop and implement preservation plans for their respective states.

OBSIDIAN: A black or dark-colored volcanic glass.

OSMONIC PURIFICATION: A nonelectric process related to electrodialysis. It uses ionic and osmotic forces to separate salts from brine.

OSMOTIC MEMBRANE: A selective membrane that allows passage of some ions and not others.

OVERDRAFT: Withdrawal of ground water in excess of replenishment.

PENDANT: A downward projection of the country rock into the top of an igneous intrusion.

PERCHED GROUND WATER: Unconfined ground water separated from an underlying main body of ground water by an unsaturated zone.

PERLITIC: Said of the texture of glassy igneous rock that has cracked due to contraction during cooling.

PERMEABILITY: Ability of a rock, sediment or soil to transmit a fluid without impairment of the structure of the medium. A measure of the relative ease of fluid flow under unequal pressure. The customary unit of measurement is the darcy. It is equivalent to the passage of one cubic centimeter of fluid, of one centipoise, viscosity, flowing in one second, under a pressure differential of one atmosphere, through a porous medium having a cross-sectional area of one sq. cm. and a length of one cm.

PHREATOPHYTIC VEGETATION: A plant type that derives its water supply from the zone of saturation or through the capillary fringe and is characterized by a deep root system.

PHYSIOGRAPHIC MAP: A perspective symbolic map which shows local relief and other physical features.

PISCICULTURE: Fish culture, raising fish.

PLAYA LAKES: Dry, vegetation-free, flat-floored area composed of stratified sediments representing the bottom of a completely closed desert basin. As playas have no external drainage, they become filled with alluvium; sometimes they are partially filled with water, which quickly evaporates and leaves a mineral residue.

PLEISTOCENE: The epoch forming the earlier part of the Quaternary period, roughly 1 or 2 million years ago to about 10,000 years ago; during this epoch there was widespread glacial ice.

PLUG: (a) A vertical, pipe-like body of magma that represents the conduit to a former volcanic vent; (b) a crater filling of lava, the surrounding of which has been removed by erosion.

PLUGGING: (1) chemical precipitation of solids in a formation around a well bore resulting in clogging the pore spaces and/or fractures in which the fluid flows; (2)the process of stopping the flow of water in strata penetrated by a borehole or well so that fluid from one stratum will not escape into another or to the surface; especially the sealing up of a well that is dry and is to be abandoned.

PLUTON: An igneous intrusion.

PORE PRESSURE: The hydrostatic pressure of the water in the pore space of a soil.

POROSITY (EFFECTIVE): The ratio of the continuous void space (through which water can move) to total volume, measured at a point in a flow system.

POTASSIUM-ARGON (K-AR) AGE DATE: Determination of the age of a mineral or rock in years based on the known radioactive decay of potassium 40 to argon 40.

PRACTICAL SUSTAINED YIELD: The amount of water that could be extracted from a ground-water basin without detrimental effects.

PRECAMBRIAN: All rocks formed before Cambrian time.

PUMICE: A light-colored, vessiculalr glassy rock usually having the composition of rhyolite, formed from pyroclastic volcanic action.

PYROCLASTIC: Pertaining to clastic rock material formed by volcanic explosion or aerial expulsion from a volcanic vent.

QUATERNARY: The period of time from the present to 1.5 to 2 million years ago (see Geologic Time).

QUARTZ MONZONITE: A coarse-grained igneous rock containing major plagioclase, orthoclase, and quartz, with minor biotite, and other iron and magnesium-rich silicate minerals.

RAPTORIAL: Preying upon other animals.

RAPTORS: Birds of prey.

RECHARGE: The process involved in the absorption and addition of water to the zone of saturation.

RESERVOIR ROCK: A natural rock which contains liquids and/or gases. In general, the fluid is contained in pore spaces between rock grains or in fractures.

REVERSE OSMOSIS: Pure water is separated from a solution by using pressure to force the pure water through a selective membrane.

RHYOLITE: A group of extrusive igneous rocks, generally porphyritic and exhibiting flow texture, with phenocrysts of quartz and alkali feldspar in a glassy ground mass. The extrusive equivalent to granite.

RIGHT-LATERAL FAULT: A strike-slip fault where the opposite sides of the fault are offset to the right with respect to each other.

RIPARIAN: Occurring along the bank of a stream or other body of water.

ROTATIONAL SLIDE: A landslide in which shearing takes place on a well-defined, curved shear surface, concave upward in cross-section, producing a backward rotation in the displaced mass.

SATELLITES (BATHOLITH): A smaller, secondary body associated with a batholith.

SCALE: The proportionate size relationship between an object and the surroundings in which the object is placed.

SCENIC QUALITY: The degree of harmony, contrast, and variety within a landscape.

SCENIC QUALITY CLASS: The value (A, B, or C) assigned a scenic quality rating unit by applying the scenic quality evaluation key factors which indicate the relative visual importance of the unit to the other units within the physiographic region in which it is located.

SCHOOL LANDS: Public lands (normally the 16th and 36th sections of each township) originally granted to the State of California by the Federal government to use or dispose of for the support of public education; many of these sections have since been disposed of the state, although usually mineral rights were reserved.

SCORIA: Vesicular, cindery form of basaltic rock due to the escape of volcanic gases before solidification.

SEDIMENTARY RESERVOIR: See Ground Water Basin.

SEDIMENTARY ROCK: Rock formed from accumulations of sediment. Sediment may consist of rock fragments, the remains or products of animals or plants, the product of chemical action or evaporation, or combinations of these. Sedimentary rocks are characteristically deposited in horizontal layers.

SEISMICITY: The phenomenon. of the earth's movements and vibrations, particularly earthquakes.

SELDOM SEEN: Portions of the landscape which are generally not visible from high and medium visual sensitivity level observer positions, and which are visible beyond approximately 15 miles from these positions.

SHEET EROSION: Erosion in which thin layers of surface material are gradually removed from an extensive area of gently sloping land by broad sheets of running water rather than streams.

SILICIC: A silica-rich igneous rock or magma.

SIMULATION: The realistic visual portrayal which demonstrates the perceivable changes in the landscape features of a proposed management activity through the use of photography, artwork, computer graphics, and other such techniques.

SOLUBILIZE: To make soluble or increase solubility of; to increase the amount of substance that will dissolve in a given amount of another substance.

SPECIFIC CAPACITY: The well discharge divided by the drawdown, expressed in English units as gallons per minute per foot drawdown.

SPECIFIC YIELD: The ratio of the volume of water, a given mass of saturated rock or soil will yield on the average and after a long period, by gravity to the volume of that mass.

STOCK: An igneous intrusion that is less than 40 sq. mi. in surface exposure, and resembles a batholith except in size.

STORAGE: Water naturally detailed in a drainage basin, e.g., ground water.

STRATIFICATION: The parallel layered structure of sedimentary rocks.

STRATIFIED RANDOM SAMPLE: A sample gathered so that each member of each defined sub-group with in the population sampled has an equal chance of being included within the sample.

STRUCTURAL PROVINCE: A region whose geologic structure differs significantly from those of adjacent regions. It is generally very similar to a physiographic province.

SUBVENTION: An agreed-upon return by the state, of a portion of sales tax revenues, to the counties (and cities, if applicable) where it was collected.

TECTONIC STRESS REGIME: The combination of regional earth forces that control geologic processes such as faulting, folding, erosion, and resulting topographic features and geologic structures.

TERRESTRIAL: (a) Pertaining to the earth; (b) pertaining to the earth's dry land.

TERTIARY: The period of time from about 2 to 65 million years ago (see Geologic Time).

TEXTURE: The interplay of light and shadow created by the variation in the surface of an object; the visual result of the tactile surface characteristics.

THERMAL FEATURES: Natural features associated with heat, such as hot springs, geysers, fumaroles, steaming ground, volcanic gases, etc.

TUFF: A compacted pyroclastic deposit of volcanic ash and dust that may contain up to 50 percent nonvolcanic sediments.

UNDERFLOW: The flow of ground water through the soil or a subsurface stratum.

UP-GRADIENT: See Hydraulic Gradient.

VARIETY: The state or quality of being varied and have the absence of monotony or sameness.

VISUAL RESOURCE: The land, water, vegetative, animal, and other features that are visible on all lands (scenic values).

VISUAL RESOURCE MANAGEMENT CLASS: The degree of visual change that is acceptable within the characteristic landscape. It is based upon the physical and sociological characteristics of any given homogeneous area and serves as a management objective.

VISUAL RESOURCE MANAGEMENT (VRM): The planning, design, and implementation of management objectives to provide acceptable levels of visual impacts for all BLM resource management activities.

VISUAL SENSITIVITY LEVEL(S): An index of the relative degree of user interest in scenic quality and concern and attitude for existing or proposed changes in the landscape features of an area in relation to other areas in the planning unit.

VOLCANICS: Those igneous rocks that have reached or nearly reached the earth's surface before solidifying.

WATER TABLE: The surface between the zone of saturation and the zone of aeration. Often this is the water level in a well.

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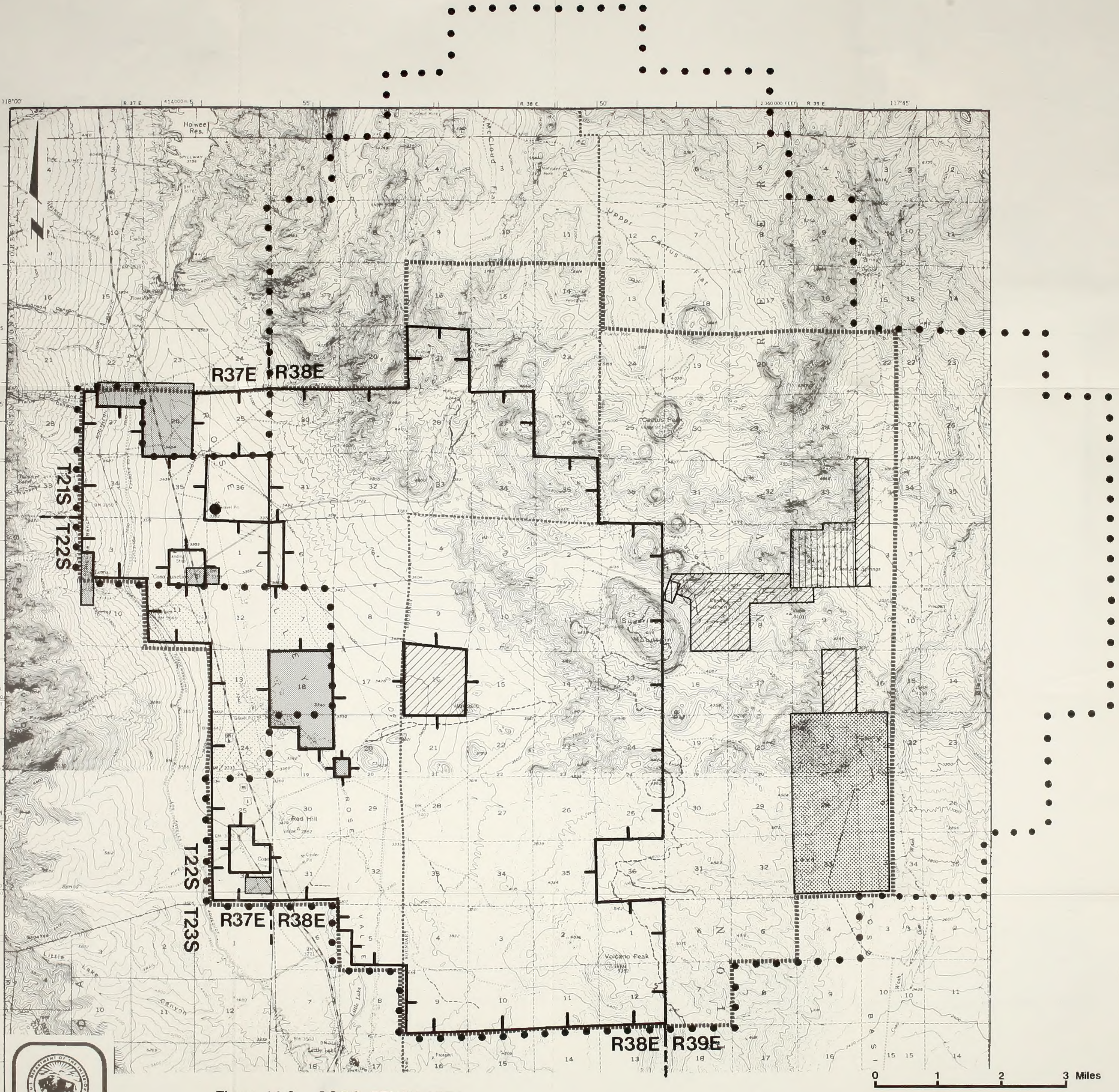


Figure 1.1-2 COSO STUDY AREA

National Historic Register Site

Navy Fee-acquired Lands

Available for Subsurface Access Only

Non-competative Lease Applications

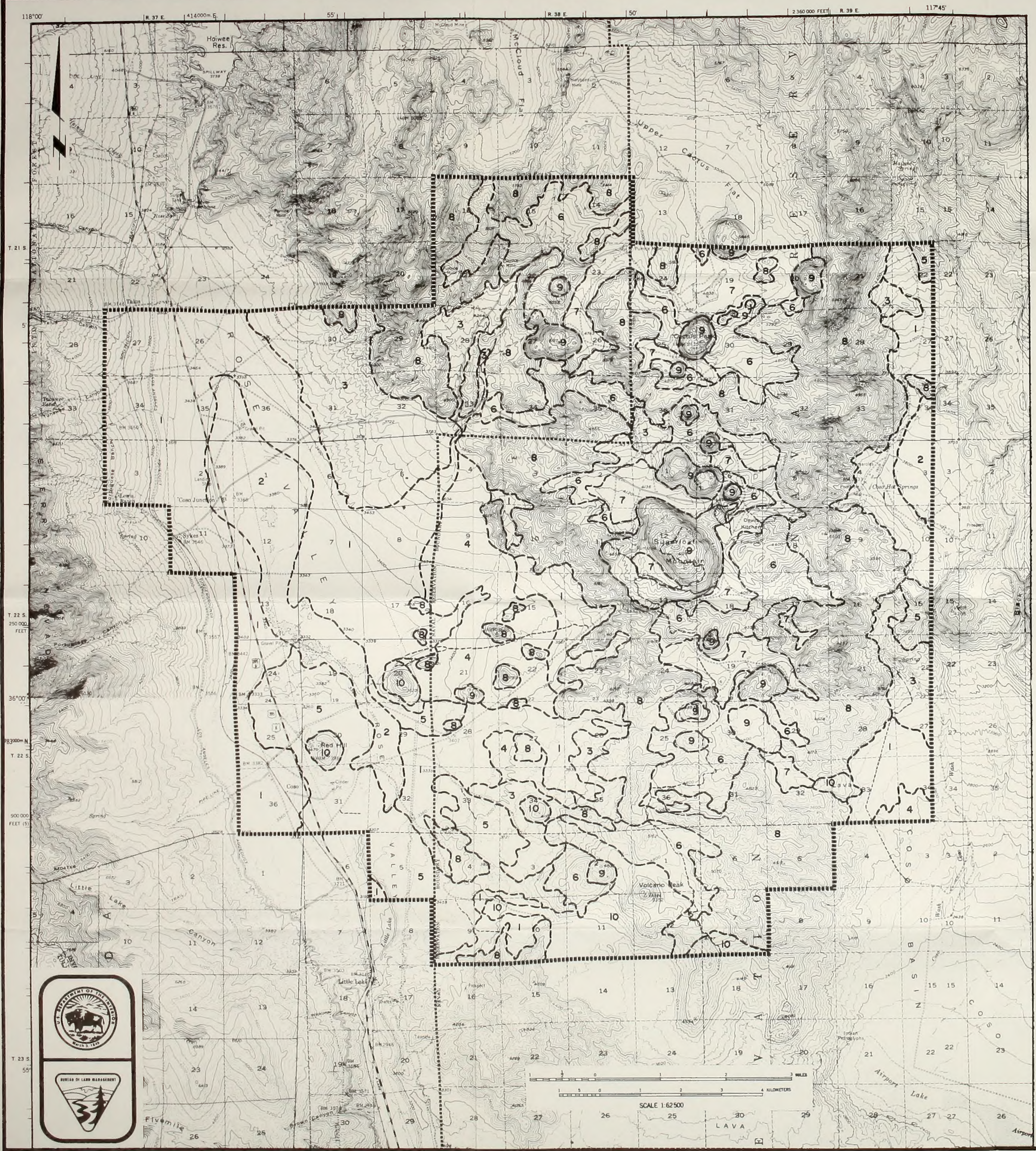
Water Resource Management (Protective Water Withdrawal)

Private Ownership

State Ownership

KGRA Boundary

CGSA Boundary

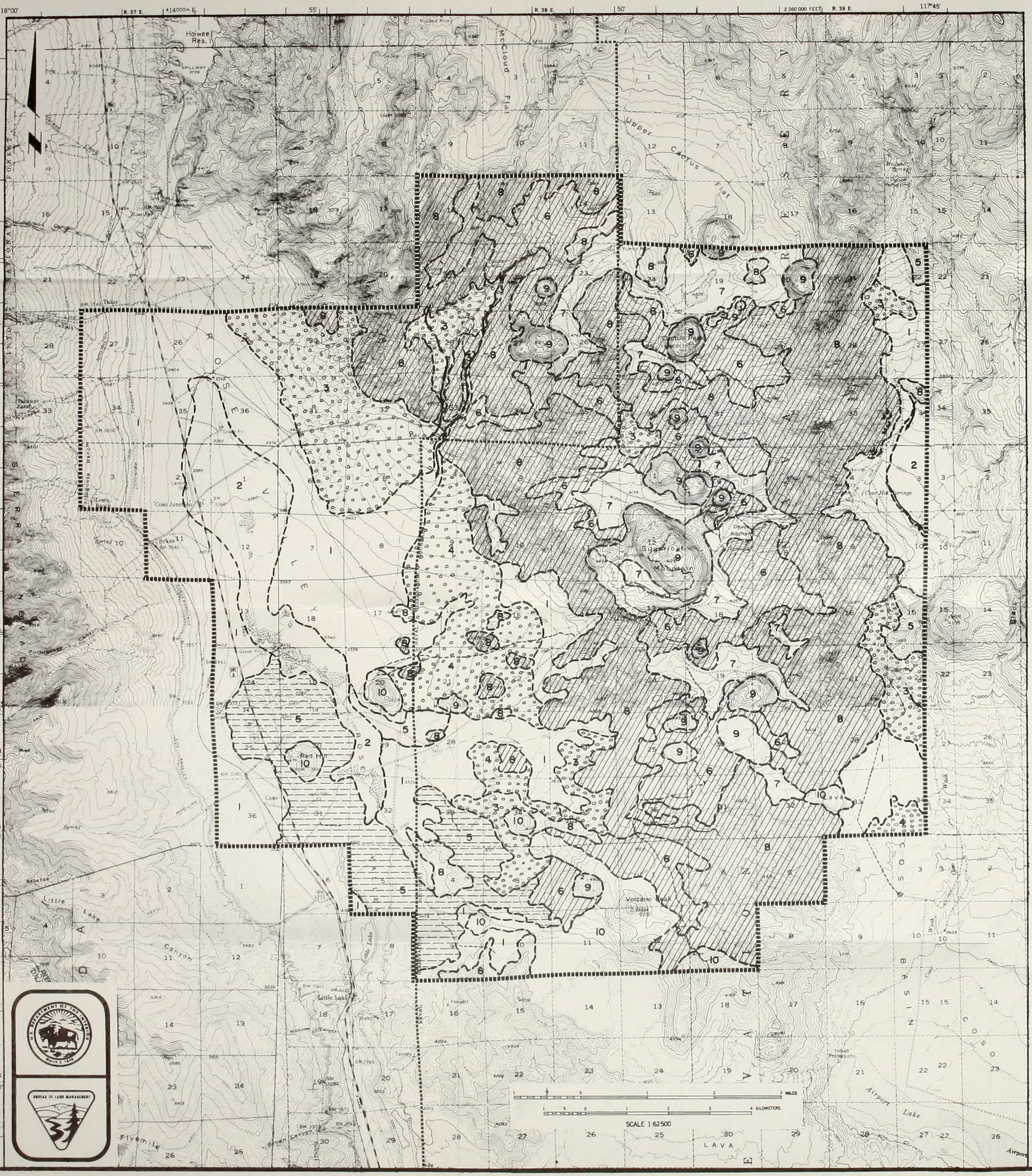


EXPLANATION

DESCRIPTION

Map Symbol	Soils on Valley Floors, Alluvial Fans and Terraces
1	Dunmovin
	Deep, nearly level to moderately sloping, somewhat excessively drained sandy soils; formed in alluvium
2	Dunmovin-Lavic-Wasco Variant
	Very deep, nearly level, somewhat excessively to well drained sandy and loamy soils; formed in alluvium
3	Alko Variant-Joshua Variant-Nebona Variant
	Very shallow to deep, gently sloping to moderately steep, well drained, cobbly sandy soils with hardpans; formed in alluvium
4	Alko Variant-Dunmovin Variant-Nebona Variant
	Very shallow to deep, gently to moderately sloping, somewhat excessively to well drained soils with hardpans; formed in alluvium
	Soils on Uplands and Upland Basins
5	Gass Variant-Garlock Variant-Sparkhule
	Shallow to moderately deep, moderately sloping to moderately steep, well drained cobbly sandy and loamy soils; formed in basalt and cinders
6	Maynard Lake Stumble, steep
	Deep, moderately steep to steep, somewhat excessively drained sandy soils; formed in rhyolite tuff and volcanic ash deposits
7	Maynard Lake-Stumble, sloping
	Very deep, nearly level to strongly sloping, somewhat excessively drained sandy soils; formed in alluvium from rhyolite tuff and volcanic ash deposits
8	Coso-Rock Outcrop
	Very shallow to shallow, moderately steep to steep, somewhat excessively drained stony loamy soils; formed in granite; and rock outcrop
9	Rubble Land-Torriorthents-Rock Outcrop
	Moderately deep, steep to very steep, excessively drained stony loamy soils on rhyolite domes; rubble land and rock outcrop
10	Cinder Land-Lava Flows
	Map Unit Boundary

PLATE 2.6-1 GENERAL SOILS MAP



EXPLANATION

DESCRIPTION

Map Symbol	Soils on Valley Floors, Alluvial Fans and Terraces
1	Dunmovin
	Deep, nearly level to moderately sloping, somewhat excessively drained sandy soils; formed in alluvium
2	Dunmovin-Lavic-Wasco Variant
	Very deep, nearly level, somewhat excessively to well drained sandy and loamy soils; formed in alluvium
3	Alko Variant-Joshua Variant-Nebona Variant
	Very shallow to deep, gently sloping to moderately steep, well drained, cobbly sandy soils with hardpans; formed in alluvium
4	Alko Variant-Dunmovin Variant-Nebona Variant
	Very shallow to deep, gently to moderately sloping, somewhat excessively to well drained soils with hardpans; formed in alluvium
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10	Cinder Land-Lava Flows
	Map Unit Boundary

SOIL SENSITIVITIES

- Highly erosive soils
- Soils overlying hardpans
- Expansive clayey soils
- Areas subject to periodic flash floods
- Landslides
- Playas - sensitive to compaction when wet

PLATE 2.6-2 SOIL SENSITIVITIES